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CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

The communications I've received from members of Central Association indicate loyal support of the association's program. Those who are responsible for carrying out its projects are serving the members well. The anniversary publication, *Fifty Years of Teaching Science and Mathematics*, is on schedule. This contribution will help mark the association's Fiftieth Anniversary Convention in November 1950 as a significant event in the long history of successful conventions.

As we plan together for this event we wish to capitalize upon the past as a means of clarification of present and future opportunity. We are proud of our record. We do not, however, feel complacent. The contributions in this century of science and mathematics to our civilization have been unprecedented. Likewise the challenges created by such contributions are without precedent.

As teachers of children, we share a grave responsibility. As teachers of science and mathematics we share special opportunities. As we meet in convention at the Edgewater Beach Hotel in Chicago on November 24, 25, our purpose will be to help clarify that responsibility and those opportunities. The beginning of the twentieth century marked the birth of significant emphases and trends in education including the birth of Central Association. At this mid-point in the century, we pause to take stock and set our sight; for the crucial and, we trust, successful performance of our duties.

Your suggestions are sought and welcomed. Your cooperation makes Central Association what it is and will make it what it can become.

PAUL L. TRUMP, President
Central Association of Science
and Mathematics Teachers

USING CARTOONS IN THE SCIENCE ROOM

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For several semesters, I have used cartoons that appeared in the local newspapers and popular magazines. These cartoons were selected on the basis of having something scientific that was humorous to the reader. They included cartoons with and without lines. At times it was merely something in the cartoon that was unrelated to the "punch line" but could apply to an area in the science course of study, which determined its selection.

The cartoons were cut out and mounted on index cards (4″ by 6″) suitable for filing and appropriate for use in an opaque projector. Since cartoons appeal to certain levels of intelligence and education, an evaluation of each cartoon was made before using it in the classes. A fairly reliable standard was drawn up by choosing certain representative cartoons, and mounting them in an accessible spot where all the class could see them, such as a bulletin board near the door. Certain grades react to some cartoons more than others. By observing the reaction of the classes, a fair judgment of the "age level" of some cartoons was made and the other cartoons were judged from the samples. Any negative reactions to the cartoon later rectified any mistakes made in classification.

The most effective use of the material was either at the introduction to a new unit or at the termination of one. While projecting regular pictures concerning the unit under study, a cartoon injected now and then not only increased the value of the cartoon but also broke up any monotony that may have developed during the lesson. Experience proved they should not be used as a lesson by themselves.

In selecting the cartoons, it is well to keep in mind the type that is desired and the purpose of the selection, as any cartoon will not do. Each cartoon should be able to pass rigid censorship and be able to fit into a classification that realizes our objectives. Assuming the cartoon has nothing offensive and is suitable for the science class, it should be filed according to subject area and grade level.

Regardless of the subject, the most effective teaching cartoons generally fit into a general pattern, such as the following:

(1) The safety cartoon. The cartoon depends upon the results of disregarding safe practice or scientific method. ("What is wrong here?")
(2) The application cartoon. This cartoon usually depends on the application or lack of a general scientific concept or principle for its humor.

(3) Possibility cartoons. Cartoons of this sort usually raise a question (in a child's mind) of whether or not an act is scientifically possible or probable.
(4) Artist's mistakes. These depend on the artist's ignorance of scientific facts (or his lack of application of them in his drawings). The humor of the cartoon may not depend on the cartoon's connection with science material, but the sketch may be very obviously scientifically incorrect. (E.g. insects having only two legs, etc.)
(5) Absurd comment cartoon. This type is closely related to #2. It differs a bit insofar as it depends on ridiculous statements made by a character in the cartoon. The statements can be made by animals, which may make it humorous or by humans who show their ignorance of common scientific knowledge.

Obviously many cartoons fit into more than one or two of these groups. However their classification is important only for the teacher's purpose in using any particular cartoon, in a lesson. He can use them to:

(A) Test his children's knowledge of the subject before beginning a unit.
(B) Test the effectiveness of his own lessons and planning.
(C) Raise problems in the minds of the children for stimulation.
(D) Review lessons.
(E) Emphasize some particular portion of a lesson that otherwise might be weak.

Upon the introduction of the cartoons into the lessons, the children may react to the cartoons as merely something that may be comical. If it is left as that, the purpose is lost. A little ingenuity on the teacher's part will start the pupils in trying to analyze what really makes the cartoon humorous, or what is wrong with the picture. This is where science enters, since the cartoons were selected for this purpose. Humor is a bit difficult to define and no joke appeals to everyone. Regardless of how many may enjoy the joke, the effective scientific use of the cartoon depends solely on the teacher. Suitability of the cartoon and commentary are important.

In the beginning the collection of appropriate cartoons is limited by the literature available to the teacher. After a while however, the pupils will supply him with innumerable cartoons. Most of the cartoons submitted may be useless for the purposes of the teacher. Many will be suitable for future presentation and will be indicative of the student's enthusiasm. Some show the pupil's ability to analyze the cartoons in a scientific manner. (On some occasions, a few talented children submitted some of their own science cartoons.)

In addition to serving the purposes of the teacher, as suggested, there were certain values that compensated for the use of the cartoons.

(1) Students became more aware of scientifically dangerous situations.
(2) They were able to recognize many applications of scientific facts, principles, etc.
(3) They became more critical of drawings and illustrations, (scientifically correct).
(4) They recognized how some scientific "facts" (which they may have deemed insignificant) made some situations ridiculous.
(5) They became more observant.
(6) They tended to analyze situations more carefully.
(7) Students were more attentive during projections.
(8) Several saw the advantage of using scientific method to other methods.
(9) Constructive ideas were presented to rectify or improve situations. These showed deep thought and reasoning.
(10) Questions arose in their minds which stimulated further study.
(11) Many comments showed application of classroom science.

SCIENCE TEACHERS FELLOWSHIPS AT M.I.T.

Science Teachers Fellowships provided by a grant from the Westinghouse Educational Foundation will bring 50 high and preparatory school teachers of science to the Massachusetts Institute of Technology for six weeks, beginning on Wednesday, July 5, 1950.

Designed to provide a review of fundamental sciences as well as a survey of recent scientific advances, the program will include lectures and demonstrations by many prominent members of the M.I.T. faculty. It will be under the general direction of Professor Francis W. Sears, chairman of the Institute's Summer Program for Science Teachers Committee.

The fellowship program is made possible by a grant of $62,500 from the Westinghouse Educational Foundation, made in 1949 to provide 50 M.I.T. Science Teachers Fellowships of $250 each to be awarded each summer from 1949 to 1954.

The 1950 program is open to science teachers in high and preparatory schools throughout the United States who are college graduates or have equivalent qualifications to carry on the courses. Applications must be made by April 1, 1950.

Dr. James R. Killian, Jr., president of the Institute, described the 1950 Science Teachers Program as a special service designed to help teachers keep pace with and be qualified to interpret the latest developments in science.

The program will include a review of important concepts in physics and chemistry presented by those in charge of freshman instruction in these subjects at M.I.T., and will cover recent developments in the fields of physics, chemistry, biology, meteorology, geology, and aeronautical engineering. The summer program begins with registration on Wednesday, July 5, and continues through August 11.

SULFONATION OF ORGANIC COMPOUNDS*

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The title of this paper as it appears on your program is quite general, and, as you no doubt realize, can not be adequately covered even in a most general manner, during the time allotted for this presentation. Consequently, this paper limits itself mainly to a consideration of one phase of the field suggested.

When your chairman first asked if I would speak to you on this occasion, I was at a loss to know what would be appropriate and of most interest to you as a group. All of you have in common an interest in teaching chemistry, but the field is so broad that to pick a specific topic of interest to all seemed an impossible assignment. I tried to think of a limited area in which each of you feels at home from which I would select the topic for this paper. After consideration of many such areas, the one that seemed to fit these stipulations best is the chemistry of sulfuric acid. Sulfuric acid being the most widely used chemical other than water, and holding such a prominent place in the presentation of general chemistry, seemed most worthy of consideration. Being an organic chemist, my thoughts turned to the application of sulfuric acid as a sulfonating and sulfating agent in organic reactions.

Sulfonation is a process whereby the union of the $-SO_3H$ group to a carbon or nitrogen of an organic compound is effected. Sulfation is the process whereby esters of sulfuric acid are formed. The sulfonic acid formed in a sulfonation reaction has the S-atom attached directly to a C-atom, while the sulfuric acid ester formed in sulfation has the S-atom attached to an O-atom which is attached to the carbon.

A number of sulfonating and sulfating agents are used (1a, b, c, d). The selection of the agent and the technique employed will be governed by such factors as the chemical and physical properties of the organic compound as well as by the economics of the competitive methods. The principal agents now in use include: (1) sulfuric acid; (2) oleum (solution of SO_3 in 100 % H_2SO_4); (3) sulfur trioxide alone; (4) acid sulfates and polysulfates; (5) chlorosulfonic and fluorosulfonic acids; (6) sulfur dioxide; (7) sulfites and acid sulfites; (8) hyposulfites; (9) N-pyridiniumsulfonic acid; (10) dioxanesulfotrioxide; (11) aminosulfonic acid; (12) sulfuryl chloride; (13) dimethyl and diethyl sulfates; and (14) methoxysulfone chloride.

One of the most powerful sulfonating agents is the anhydride of sulfuric acid, sulfur trioxide, which can be used in sulfonating both

* Presented at the Chemistry Section of the Central Association of Science and Mathematics Teachers, November 25, 1949.

aliphatic and aromatic compounds. This agent alone has not been very popular in most industrial sulfonation processes because it is a solid and presents major problems in attempts to disperse it uniformly in a reaction mix. Attempts to use it in the liquid state or in highly concentrated solutions result in the freezing or caking-out of the solid causing trouble both in shipping and in plant operations.

The General Chemical Division of the Allied Chemical and Dye Corporation has recently overcome this problem by stabilizing sulfur trioxide in the liquid state and is now in industrial production of sulfur trioxide under their trade name of Sulfan.

The use of sulfur trioxide in chemical reactions is not new but the availability of the stabilized liquid form for industrial scale reactions is comparatively new. Even though there has been much research conducted on the uses of sulfur trioxide, the availability of Sulfan has greatly stimulated further investigations particularly in industry where sulfur trioxide alone has only enjoyed a very limited acceptance as a sulfonating agent. Because of the renewed interest in sulfur trioxide this paper will give special attention to its use as a sulfonating and sulfating agent in organic reactions.

The sulfonation of a hydrocarbon using sulfuric acid as the sulfonating agent may be represented by the general equation:

$$R—H+H_2SO_4 \rightarrow R—SO_2OH+H_2O \qquad (1)$$

where R represents an alkyl or aryl radical.

Using sulfur trioxide as the sulfonating agent, the sulfonic acid will be formed without the formation of water.

$$R—H+SO_3 \rightarrow R—SO_2H. \qquad (2)$$

The sulfation of an alcohol using these same reagents may be represented as follows:

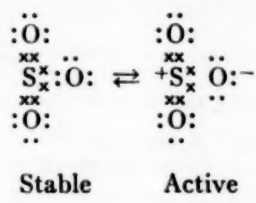
$$R—OH+H_2SO_4 \rightarrow R—OSO_2OH+H_2O \qquad (3)$$

$$R—OH+SO_3 \rightarrow R—OSO_2OH. \qquad (4)$$

In both types of reactions the advantage of the sulfur trioxide is the absence of water as a product of the reaction. The water formed when sulfuric acid is used gradually dilutes the acid until the reaction finally stops unless some means of removing the water during the reaction is employed.

It might be well to consider at this point the mechanism of the reaction of sulfur trioxide with organic compounds. Sulfuric acid does not seem to react appreciably with saturated aliphatic hydrocarbons, but sulfur trioxide will react under favorable conditions to give aliphatic sulfonic acids. One explanation for the mechanism of this reaction may be represented as follows:

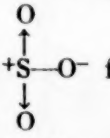
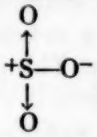
Through resonance sulfur trioxide probably is made up of two types of molecules, one stable and the other active.

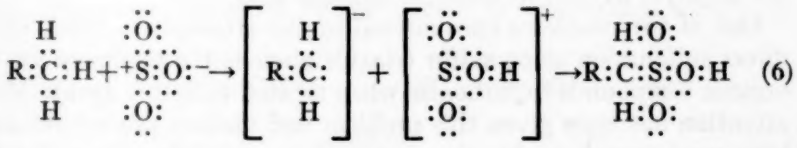


(5)

Stable Active

The shift of the pair of electrons from the double bond between the sulfur and oxygen to the oxygen atom increases the electron density at the oxygen and leaves the sulfur atom deficient in electrons. The result is an increase in polarity and the establishment of a dipole, the sulfur atom being positive and the oxygen negative. In this form the sulfur trioxide will attract the polar portion of other molecules or will induce polarity in non-polar molecules in its vicinity. If the inductive effect is sufficiently great a chemical reaction may take place between this molecule and the molecule of sulfur trioxide.

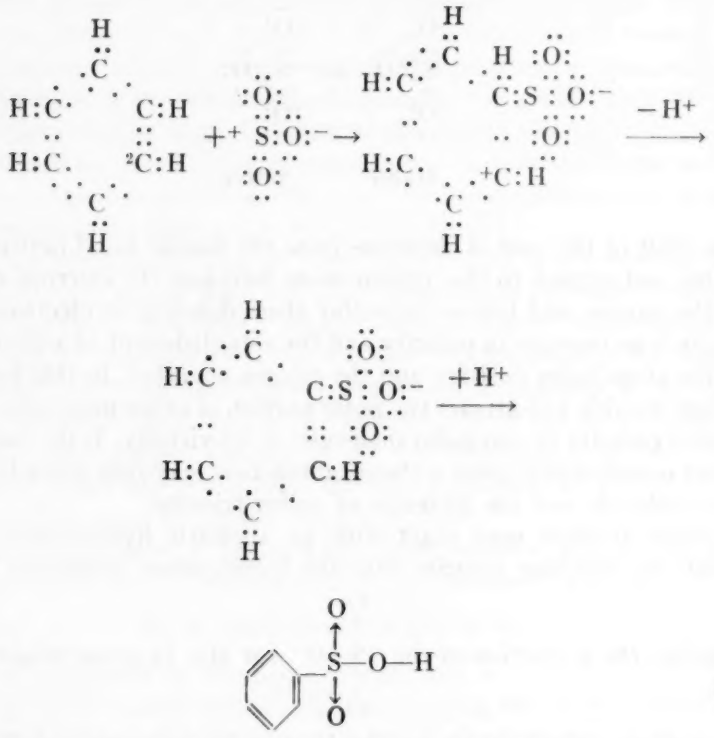
Sulfur trioxide may react with an aliphatic hydrocarbon (non-polar) by inducing polarity into the hydrocarbon moledule. In the reaction the attraction of the  for the H-atom weakens the attraction of the C-atom for the H-atom by inducing a shift of the pair of electrons between the C-atom and the H-atom toward the carbon. When the attraction of the C-atom and the  for the H-atom are equal the transition point has been reached. At this point the reaction may go in either direction; a high concentration of SO_3 will favor the formation of the sulfonic acid.



(6)

The negative carbon ion is formed by the loss of the H-atom, and the S-atom, being deficient in electrons, shares the unshared pair of electrons left on the C-atom to form the sulfonic acid.

Sulfonation of an aromatic hydrocarbon using sulfur trioxide as the sulfonating agent may be represented as follows:



(7)

The active resonance form of the sulfur trioxide induces a shift of a pair of electrons from the double bond between C_1 and C_2 to C_1, producing a deficiency of electrons on C_2 making C_2 positive and C_1 negative. This pair of electrons is then shared with the S-atom which is deficient in electrons. The bond between C_1 and its H-atom is so greatly weakened by the presence of the positive sulfur atom that the H-atom (proton) is released leaving the pair of electrons with the carbon. These electrons are then shared with C_2 to again complete its shell of eight electrons. The proton shares a pair of electrons with the negative oxygen to form the sulfonic acid.

One of the problems encountered in the attempts to bring about direct sulfonation using sulfur trioxide alone is the tendency for the organic compounds to carbonize when treated with this agent. Much attention has been given this problem and various procedures have been used to reduce this charring, such as dissolving the sulfur trioxide in inert solvents; by diluting the SO_3 vapors with a gas such as nitrogen; and by forming SO_3 adducts which will release the sulfur trioxide during the sulfonation reaction.

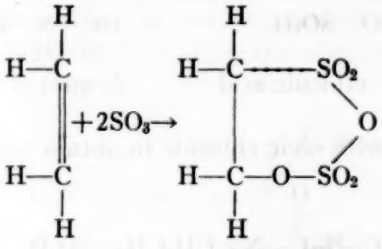
Sulfonation with SO_3 Alone

Paraffin Hydrocarbons. Hexane, heptane, octane and the higher paraffins react with sulfur trioxide to form disulfonic acids (2).

$$C_8H_{18}+2SO_3\rightarrow C_8H_{16}(SO_3H)_2. \qquad (8)$$

The sulfonation of kerosene and other petroleum fractions is described in the literature (3, 4).

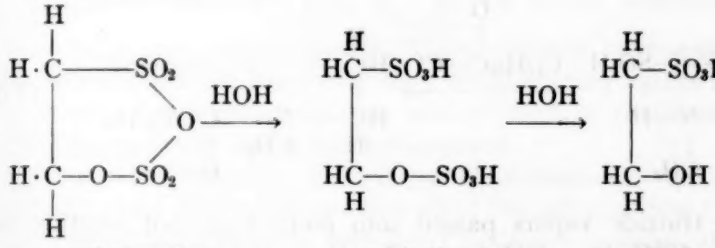
Olefins. The low molecular weight olefins tend to char with sulfur trioxide. However, SO_3 does react with ethylene to give carbyl sulfate (5).



(9)

carbyl sulfate

Carbyl sulfate is readily hydrolyzed first to ethionic acid and then to isethionic acid (6).

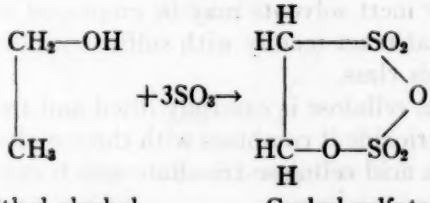


(10)

carbyl sulfate ethionic acid isethionic acid

Higher olefins give corresponding homologs of carbyl sulfate and hydrolysis products (7).

Alcohols. At elevated temperatures ethyl alcohol is oxidized to ethyl acetate by sulfur trioxide, but at low temperatures sulfur trioxide vapors are absorbed by the alcohol to form carbyl sulfate (8).

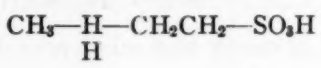


(11)

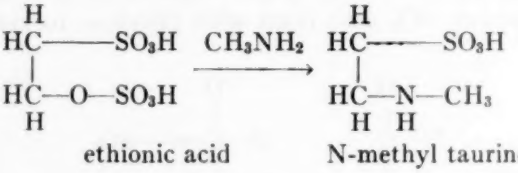
Ethyl alcohol Carbyl sulfate

Carbyl sulfate and ethionic acid are of interest in making acid resisting soaps and surface active agents.

If methylamine is added to ethyl alcohol in the preparation of isethionic acid (9), N-methyl taurine,

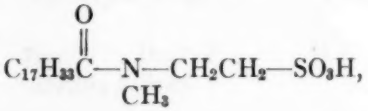


is formed.

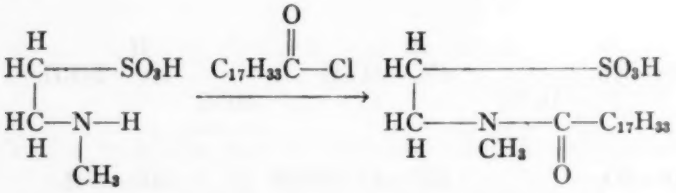


(12)

This is condensed with oleic chloride to obtain

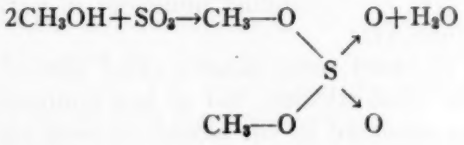


a powerful wetting agent used in softening artificial silk and other textiles.



(13)

Sulfur trioxide vapors passed into methyl alcohol solution in CCl_4 at $-10°C.$ to $-5°C.$ forms dimethylsulfate in almost quantitative yields.



(14)

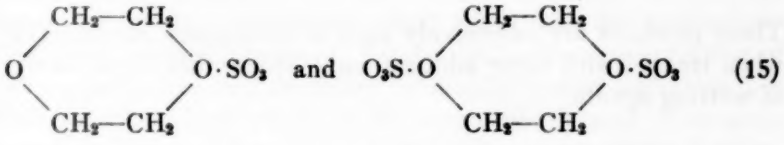
Comparatively inert solvents may be employed in the sulfonation of compounds that react readily with sulfur trioxide. Aromatic compounds fall in this class.

Cellulose. When cellulose is carefully dried and treated with dilute vapors of sulfur trioxide it combines with three moles of SO_3, without charring, to form acid cellulose trisulfate which can be isolated as a salt (10).

Sulfonation with SO_3 Adducts

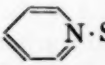
All sulfonating agents are more or less stable addition products of sulfur trioxide. The more readily an atom donates an electron pair, or the more basic it is, the less active is the addition compound with sulfur trioxide as a sulfonating agent. The most active sulfonating agents are sulfur trioxide and its addition product with itself; the next most active are the addition compounds with the mineral acids, (chloro- and fluorosulfonic acids) and with sulfuric acid (pyrosulfuric acid). Certain ethers, such as dioxane, form stable addition complexes with sulfur trioxide that are active sulfonating agents. The addition compounds with bases, such as pyridine are the least active.

Dioxane sulfotrioxide is formed by the addition of sulfur trioxide to dioxane.

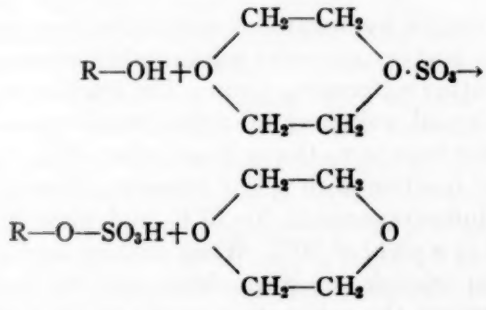


(15)

These addition products react as sulfonating agents with about the same reactivity.

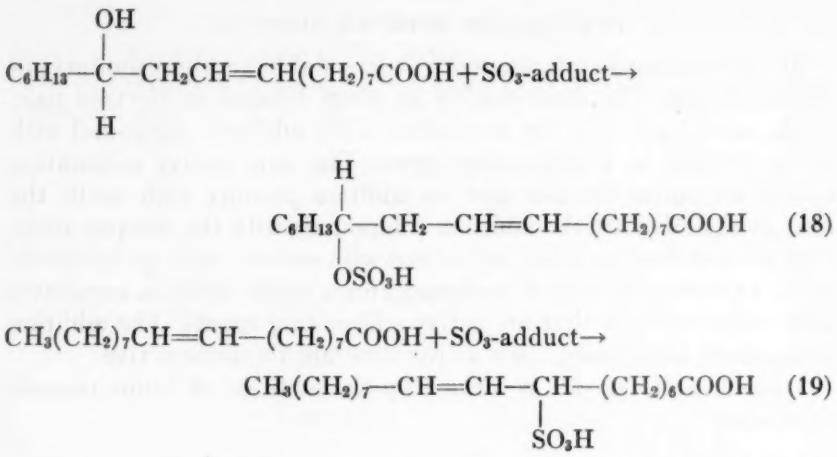
N-pyridiniumsulfonic acid,  , is the addition product of pyridine and sulfur trioxide. These adducts have quite general application and are commonly used as sulfonating agents in organic reactions. N-pyridiniumsulfonic acid is used in reactions where a less vigorous sulfonating agent is required.

Dioxanesulfotrioxide and N-pyridiniumsulfonic acid convert straight chain olefins into compounds of the carbyl sulfate type. They convert primary alcohols into alkyl hydrogen sulfates, the higher members having valuable detergent properties.



(17)

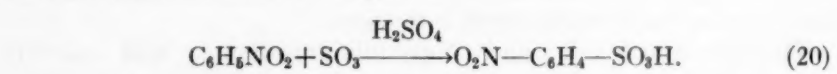
Fatty acids (11) and vegetable oils may be sulfated and/or sulfonated when treated in CCl_4 solution with these agents.



These products are extensively used as detergents. Amides (12, 13) when treated with these adducts make up another important group of wetting agents.

Oleum as a Sulfonating Agent

The ease with which aromatic hydrocarbons react with sulfuric acid to form sulfonic acids is one of the characteristics that differentiate them from the paraffin hydrocarbons. Many aromatic compounds are readily sulfonated by this agent. However, aromatic compounds such as nitrobenzene (14), require a more vigorous sulfonating agent and in such cases oleum is required.



In compounds easily sulfonated with H_2SO_4, oleum is usually required if two or more sulfonic acid groups are to be introduced into the molecule.

The reaction of aromatic hydrocarbons with sulfur trioxide is practically instantaneous and occurs under mild conditions compared to the requirements of other sulfonating agents. The reaction of benzene with sulfuric acid (equal volumes) at reflux temperature reaches equilibrium only after twenty to thirty hours when 80% benzene is sulfonated (15). The reaction with sulfur trioxide (chloroform solution) is practically instantaneous at 0−10°C. and benzene sulfonic acid can be isolated in a yield of 90%. When sulfuric acid is used as the solvent for sulfur trioxide, we have oleum, and the per cent of SO_3 dissolved determines the sulfonating power of this agent. The strength of the oleum to use in a specific reaction will depent on the requirements of the compounds being sulfonated.

The most common side reaction in the sulfonation of aromatic compounds is the formation of sulfones. Sulfone formation is favored by an excess of the compound being sulfonated and by the use of a very active sulfonating agent. This reaction, like sulfonation, is a reversible process. Phenylsulfone may be converted by sulfuric acid into benzene sulfonic acid.

$$2C_6H_6 + SO_3 \xrightarrow{H_2SO_4} C_6H_5{-}\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}{-}C_6H_5 + 2H_2O. \qquad (21)$$

During the sulfonation reaction as the SO_3 of the oleum is consumed, its concentration is maintained at a fairly constant level by the addition of more sulfur trioxide. This procedure insures uniform conditions of concentration for the reaction and thus reduces the tendency for side reactions which might result from the gradual depletion of the sulfonating agent. By regulating the concentration of SO_3 at a value below that necessary for disulfonic acid formation it is possible to obtain high yields of the monosulfonic acid. This same technique is economical in sulfuric acid sulfonations where it is important to maintain a uniform strength acid.

One of the most important uses of sulfonic acids is in the synthesis of intermediates for dyestuffs. Sulfonated castor oil, and other vegetable oils have long been used in the textile, leather, paper, glue, and other industries. They are used as constituents of soaps as wetting or emulsifying agents, as aids in dyeing, and as detergents.

Let us return to Sulfan, the industrial stabilized liquid sulfur trioxide, for a brief consideration of the progress which has been made in applying it to industrial sulfonations. "Sulfan is now used either on a commercial scale, or in large pilot plants for the production of the following products: sulfoacetic acid, benzene disulfonic acid, nitrobenzene sulfonic acid, dodecylbenzene sulfonic acid, lauryl sulfate, sulfonated fatty acids, and sulfonated oils.

"In general, Sulfan may be used in three ways. It may be used (1) directly as a liquid, (2) as a liquid in the presence of another solvent, or (3) in the form of SO_3 vapors. Since sulfonations with sulfur trioxide generate considerably more heat than is true in the case of oleum or sulfuric acid sulfonations, special techniques have been worked out for various classes of organic compounds.

"In the case of the sulfonations of acetic acid and nitrobenzene, and in the di-sulfonation of benzene, the required amount of Sulfan may be introduced by dropwise addition accompanied by vigorous agitation, the reaction being carried out at approximately 110 Centigrade. In the sulfonation of the aromatic hydrocarbons and in the sulfonation of fatty acids SO_3 vapors are introduced to prevent local concen-

tration of heat which would otherwise tend to carbonize the organic molecule. Large scale pilot plants for both processes have been operated using both Pfaudler kettles and continuous pump type sulfonators. In all the above reactions, Sulfan offers acid economies because it reacts in stoichiometric proportions. This avoids neutralization of un-needed excess acid, and eliminates also extractions to achieve high active ingredients in the case of the alkylated-arylated sulfonations.

"In the case of the sulfonations of fatty acids and natural oils, an improvement in product type is noted in the use of Sulfan. The reaction is one of addition at a double bond. Two moles of Sulfan are added to one mole of fatty acid to form one mole of carbyl sulfonate. On neutralization this is hydrolyzed to form sulfuric acid and a sulfonic acid. This has several advantages over the sulfuric acid ester product formed by reaction of oleum and the double bond. This hydroxy-sulfonic acid will not dissolve upon exposure to weak acids, thus permitting washing to free the product of sodium sulfate. This also opens up new uses in the acid textile dye bath. Further, with Sulfan a much higher content of organically combined sulfur trioxide may be achieved than is found when acid or oleum are employed" (16).

In order to have a complete picture of sulfonation processes there are several factors that have not been discussed in this paper which must be considered for the carrying out of any specific sulfonation. These include, (1) *the effect of temperature* on the orientation of the sulfonic acid groups in organic compounds, on the rate and degree of reactions, and on oxidizing action; (2) *the influence of reaction time* on sulfonation; (3) *the effect of catalysts* and sulfonation aids; (4) *the effect of agitation* during sulfonations.

For those of you who wish to investigate these factors and delve further into sulfonation and sulfation reactions the following references are recommended to you in addition to the chemical journals. *Unit Processes in Organic Synthesis*, Groggins; *Organic Reactions*, Vol. III, Adams, Editor; *Organic Chemistry of Sulfur*, Suter.

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THE SIMPLE PENDULUM

AN EXERCISE IN THE ANALYSIS OF DATA

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The analysis of data is difficult for beginners. It is a trivial matter for beginning students (and older ones too!) to assemble an array of data by performing the experiment cookbook fashion, but to interpret the data is quite another matter. Instructionally we are not so successful with this. History is replete with failures, the classical case being Tycho Brahe and Kepler. What do the data mean, involves more than good rhetoric. It is the most substantial inquiry to be made in any experiment.

An elementary but highly effective exercise in the *analysis of data* is provided by the following sequence of experiments on the simple pendulum. The usual procedure is well known. The commonplace exercise is to determine g for the place, and to show that the weight of the bob has nothing to do with the period, nor does the arc, if it isn't too large! The expression for the period is taken for granted or developed as $T=2\pi\sqrt{l/g}$, and it is now said that the period varies directly as the square root of the length. How many get the "feel" of this profound mathematical announcement? We propose the following:

Adjust 3 pendulums on a *rigid* horizontal support so that their lengths are exactly 10 cm., 40 cm., and 90 cm., respectively. Clock the time for, say, 20 vibrations each, and record in tabular form. The times will be something like this: 13 seconds, 26 seconds, 39 seconds! Now ask the class if they see anything remarkable in this data! Repeat with lengths 9 inches, 16 inches, and 25 inches, and ask the question.

This writer has found this experiment, trivial as it is, to be abundantly instructive.

ILLINOIS ROCKS AND MINERALS FOR THE EARTH SCIENCE LABORATORY*

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Laboratory material suitable for illustrating mineral resources and the classification of rocks and minerals is obtainable in many cases from sources in Illinois. Coals, clays, sands, quarry products as well as a few ores may be collected within the state and because of the local occurrence, interest in them may be stimulated. This paper is intended to comment on a few such localities within the state; some of them, incidentally, also afford opportunities for other types of earth science field work.

The state of Illinois, in general, is not particularly attractive to mineral collectors as over most of the state's surface the mantle of glacial drift has blanketed the bedrock and the occasional outcrops are usually not interestingly mineralized.

Beyond or near the limits of glaciation, a few localities yield good specimens of limited variety of minerals, ores, and rocks. These areas include the old zinc-lead workings in the extreme northwestern part of the state, the fluorspar mining field in the extreme south, the formations of the Ohio and Mississippi river bluffs and adjacent hill-lands, and the various coal-mining sections. The drift and loess occasionally furnish desirable specimens.

Of these five regions, the one probably of greatest value to earth science teachers is the fluorite field along the Ohio River, as the largest producing fluorspar area in the United States. It is also of interest to earth-science teachers because of its unique geological structure as well as a fertile collecting ground for laboratory rocks and minerals. It contains the only place in the state where igneous rock outcrop as sills and dikes; specimens of an uncommon type of crystalline rock may be obtained as well as a large variety of minerals.

The fluorspar occur mainly in Hardin and eastern Pope counties but extend across the Ohio River into Kentucky. Rosiclare is the center of the mining industry. United States Geological Survey topographic maps of the Equality and Shawneetown quadrangles show the area on an approximate scale of one mile per inch.

The area has been adequatedy described in a paper by Carroll (1); both state and federal surveys have issued geological and economic reports by Bain (2), Weller and associates (3), Bastin (4) and Hatmaker and Davis (5). Schwerin (6), manager of the Victory mine at

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Elizabethtown, and King (7) of the Wickliffe, Ky., archaeological museum, have more recently published on the occurrence and uses of fluorspar, from this area.

The fluorite of the region was known to the Mound Builders, early inhabitants of the Ohio valley, who fashioned it into jewelry, (7, p. 137). The brilliant colors of the mineral also attracted the attention of the white settlers; it it mentioned as "fluate of lime" in the early issues of the *American Journal of Science,* and in the 1822 edition of the first American textbook on mineralogy by Parker Cleaveland (2, p. 12). Phillips' text, published in England in 1816 and used in America after that date, makes no mention of the Illinois deposits; a hand-written note, in a copy in possession of the writer, on the section devoted to "fluate of lime," says the mineral was "found in Virginia" (10). It may be of historical interest to note that President Andrew Jackson headed one of the early mining developments of the area; this, however was not in Illinois, but south of the river in Crittenden County, Kentucky. The pioneer iron smelting industry, based on the residual limonite ores, has long vanished from the region, but one of the two furnaces, appropriately named the Illinois, still stands near Rosiclare, a monument to the first and only use of Illinois iron ores.

The topography of this area is in great contrast to the glaciated sections of the state. From the Mississippi River a belt of hill-land stretches eastward to Hardin county and the Ohio River. It is a rugged region of mature topography and contains some of the higher elevations of the state. The river lies in a trough much below these elevations. The sedimentary Paleozoic strata have been faulted into a mosaic of blocks, probably following the intrusion of a deep-seated igneous intrusion at the eastern end of the hill-lands. The genesis of the fluorite and the associated minerals is considered to be connected with this igneous activity. Intrusive igneous rocks outcrop in a few scattered localities and are more frequently found in the mines. Both the topography and structure are extraordinarily unique, as occurring in a general region undisturbed horizontal sedimentary formations. The Geologic map of Hardin County in Weller's report shows these details.

The fluorspar deposits occur either in horizontal beds, replacing sediments and are locally termed "blanket deposits" or in nearly vertical veins, which follow fault lines and are the source of the spar of commerce. These veins also furnish the better crystallized fluorite specimens, as well as the less common sulphides. The blanket deposits are the source of the banded "coontail" spar. The crystallized specimens from the area are in the form of simple cubes and cleavage octahedrons may be split from large crystals with careful manipula-

tion. A small fraction of the fluorite recovered is clear and free of flaws; this finds use as optical spar (8).

Both galena and sphalerite occur in commercial quantities and are frequently enclosed in the calcite and fluorite vein minerals. The waste dumps from the washers generally contain material from which nice specimens of both calcite and fluorite may be made. The calcite in the veins sometimes is found in the form of scalendohedral crystals of dog-tooth spar. Quartz crystals seem to occur only in the form of tiny crystals in druses on the early deposited vein minerals. These crystals are dark or brownish-yellow and the terminal faces are the only well developed surfaces of the crystals. Chalcopyrite crystals are scarce and found only in a few parts of the mined veins. These are in the form of brassy-colored sphenoids and are of very small size. Pyrite is also a scarce mineral and is found, generally, as small crystals imbedded in the vein minerals. Cavities in the veins occasionally have stalagtite forms; these are almost always altered to limonite with the pseudomorphs of the pyrite crystals poorly preserved.

The near surface blanket deposits of the spar contain radiating crystal clusters of marcasite as well as gypsum of secondary origin. Other minerals have been reported but are less common than those just given. Barite is occasionally found in typically bladed groups of crystals of white, brown or "tiff blue" color. Stibnite apparently is very rare. Oxidized forms of the sulphides, such as cerusite, are seen as coatings on the exposed surfaces.

Typical specimens of brown iron ore, a residual limonite, are plentiful in the hill-lands near the area.

Near the fluorspar area is Cave in Rock State Park, which is of some geological interest as it contains a cavern from which the park takes its name. The cave, a small one now partially filled with residual cave-clay, is of the tube type (9, pp. 752–753).

Another Southern Illinois area of interest to the earth science teacher is the Mississippi Embayment (11) or the Illinois portion of the Gulf Coastal plain. Within, or near, the borders of the embayment area are found clays of different kinds as well as rocks of types not found elsewhere in the state. Fuller's earth, formerly used in the wool textile industry, is now employed for decolorizing gasoline. This clay is dug and processed in Pulaski County near Olmstead on the Ohio River. The geology of the region has been summarized by Lamar (12, pp. 7–12) of the State Geological Survey; a sketch map is given in the reference and the Cairo Quadrangle Map shows the topography of the area. The flat-lying Tertiary formations include the fuller's earth, probably a near-shore deposit of the coastal plain. The earth

is a mixture of extremely fine quartz grains and the clay mineral montmorillonite (13, p. 345).

During the first world war, a second type of clay was dug for use as a decolorizing agent for vegetable oils when the importation of European clays was cut off. The diggings are confined to a limited area some three miles long and perhaps half as wide in northwestern Union County near Anna-Jonesboro. A good sketch map of the area is given in a state survey bulletin (14, p. 8) and the Alto Pass quadrangle map covers the area. The clay deposits occur as patches, probably erosion remnants left behind in depressions, possibly ancient sink holes, when the coastal plain veneer was eroded off the bed rock.

The whitish, or bluish white clays, are covered by an overburden of sand or other sediments deposited by the Tertiary seas at the extreme north end of the Mississippi Embayment. They are included in the Wilcox (Lagrange) (15, p. 302) formation and, from a mineral point of view, are considered to be true kaolinite (14, p. 28) or of minerals of the kaolinite series. Lignite fragments, as well as small specimens of limonite and perhaps hematitie occur in the walls of the clay diggings.

South of the Kaolin area are the silica mines or diggings. The silica, a fine gritty white friable material, is used as an abrasive, as a filler in paints, and in ceramics. It is thought to have been formed from the insoluble residue of a silicious limestone (16, pp. 12–14), the calcite of which has been removed by solution in ground water after prolonged weathering. The chert nodules of the limestone appear to have been altered under the peculiar conditions of deep weathering, leaching, and redeposition of the silica into a peculiar white porcelain-like chert or into the compact masses of novaculite, a fine-grained material that occurs as lumps in the silica. Locally known as "ganister," the lumps are used as road material (18, p. 3). The silica, commercially called tripoli," is composed of minute quartz grains. It is white in color except when iron-stained and feels gritty to the touch (18, pp. 6–7).

Just west of the silica mines section, and in the border of the Ozark dome but on the Illinois side of the Mississippi, there is a faulted and folded section, where the geological structure has brought to the surface strata of the older Paleozoic rocks (19, p. 115). In a Silurian limestone strata, there is a compact black chert closely resembling flint in many of its characteristics. Outcrops of this chert are scarce but cobbles of it may be found in the creekbeds, particularly in that of Orchard Creek, north of the village of Thebes. On the eroded rock surface, are patches of sands and gravels, remnants of ancient

stream deposits, probably of Pliocene age. A peculiar bronze chert occurs is the gravels; the bronze tinge is merely a surface coloring due to weathering on the smooth faces of the chert. On breaking a pebble, the lighter and typical chert color may be seen. As this coloring superficially resembles "desert varnish," the bronze chert may fill a place as illustrative material for this phenomena in a teaching collection.

The sands of the embayment section are frequently highly colored and contrast sharply in this respect with the Ottawa and sea sands usually furnished in a teaching collection.

A field trip to any of these sections of southern Illinois should include a visit to the Giant City State Park, near the little town of Makanda, a short distance east of Federal Route 51. The park gets its name from the gigantic blocks of sandstone, some larger than a Chicago office building, each separated from its neighbor by deep, canyonslike slits, meeting at right angles, much like the streets of a city. This unusual feature is explained as result of the mass-slump. The massive Makanda sandstone is cut by two sets of joint planes almost at right angles and the resulting blocks have settled apart on the underlying shale strata to leave the widened point planes as straight and wide avenues. Erosion remnants of the sandstone along the cliffs form fantastic figures, each a study in differential erosion (20).

Farther north but still adjoining the Mississippi river, is the third general area of interest to the earth science teacher who is building up illustrative material for the laboratory. Stretching from the vicinity of Chester in Randolph County, northwestward for more than a hundred miles to and somewhat beyond the junction of Illinois river with the Mississippi, the region includes a belt of river-hills along the eastern border of the Ozark dome from which the Mississippian and Pennsylvanian strata dip eastward toward the Illinois Basin and disappear under the cover of the glacial drift. Topographic maps covering the area include the Chester, Baldwin, Weingarten, Crystal City-Renault, Waterloo, Kimmswick, St. Louis, Alton, St. Charles, Jerseyville and the Hardin-Brussels quadrangles. A good but small-scale sketchmap that covers most of the region is given by Robertson (21, p. 170). The gently dipping strata have, in the southern part of the area, been faulted and folded and the northern section includes the Cap-au-Gres fault that brings much older formations to the surface in Calhoun County. Weller and Sutton (36) sketch the geology of the southern portion and the Kansas Geological Society's guidebook (19, pp. 131–137) gives a more detailed discussion of the same region. For the section lying just across the river from St. Louis, Fenneman (38) gives the most data and Bowman (27) shows cross-

sections of this region. Collingswood (37) gives a resume of the northern sector.

These river-hills include the Dupo oilfield (22, 23) and the important quarrying activity of the southern sector of the area. The limestone is a typical crystalline limestone and excellent specimens may be had for the trimming. The quarries expose many cavities in the limestone that often contain minerals in nice crystal form. Among these are millerite (24) barite, fluorite and dolomite (25).

In the loess-covered foothills, limy concretions, in a variety of fantastic forms called loess kindchen, may be obtained as attractive but exceedingly fragile specimens. These are usually obtained in the roadcuts at the edge of the river trough and form interesting but easily broken specimens.

Most of the Mississippian formations are fossiliferous and on the weathered surface of the outcrops, many excellent specimens of a variety of forms may be obtained with a minimum of chipping to free them from the matrix. Near Alton, the limestone quarries furnish good trilobite casts and molds.

In the southern sector, a belt of sink-hole topography has developed a few cavernous openings from which laboratory-sized specimens of "dripstone" or "cave onyx" may be obtained.

Along Illinois river, particularly at low water stages, occasional geodes from the Warsaw beds, may be found in the stream gravels. Farther north, near the village of Niota, the geode bed outcrops in the shale banks of the creeks. These geodes often contain a thick oily bituminous substance (21) or are partially lined with crystals of a variety of minerals, including quartz, calcite, galena, sphalerite and several others not commonly found in the area. While the crystals are not large, the faces and forms are frequently excellently developed and well suited for laboratory study.

In the older beds exposed at the surface in Calhoun County is a peculiar and interesting chocolate-brown oil rock that occurs in the thin, discontinuous beds. This rock contains sufficient waxy or resinous content to ignite when heated (28, p. 225–226).

To the east of this river-hills area, in the Illinois basin, lie the coal fields, the state's most important mineral resource; besides the coal, fireclays and a few minerals suitable for laboratory work may be obtained. Most prominent among the minerals is pyrite, generally occurring as lumpy, gray nodules or in discontinuous beds in the coal seams. Sometimes the lump is iron-stained because of oxidation of the iron disulphide to limonite but generally the metallic brassy luster shows when the specimen is broken.

In a few mines, particularly in the Belleville section, the hardened roof shale may contain marcasite in the form of marcasite "suns,"

disc-like forms that vary in size from that of dime to larger than a dollar (26). These specimens are generally covered with a film of tarnish when found in the rock waste; their true color may be seen on cleaning with acid. After cleaning, the marcasite must be protected with a transparent coating of clear lacquer to prevent the action of air, which will cause decomposition of the specimen.

Clays in the Coal Measures are important commercially and in the area near St. Louis make up a larger proportion of the rock section than is general elsewhere in the Illinois basin (29). These clays are all more or less refractory and one underclay is used commercially for the manufacture of fire-brick. These clays differ in composition and physical properties from those of the areas in extreme southern Illinois and are reported to be mixtures of exceedingly fine flakes of the clay minerals illite and kaolinite (27, p. 6). As collected, the fireclays are structureless, silt-like deposits of a gray to black color.

Gypsum in the form of slender needles is sometimes found on waste heaps piled in the abandoned workings of the mines. Apparently, these have formed since the opening of the mines as the fragile crystals are too delicate to have withstood the handling of the waste rock, indeed it is difficult to get a specimen to the surface without mashing some of the crystal growths.

The fifth major collecting area lies in the extreme northwestern corner of the state, in the driftless area. It is practically co-extensive in Illinois with Jo Daviess County. It is the oldest mining section in the state; it was worked by the Indiáns at the time of the French explorations in the late 1600's (30, p. 179). Lead for munitions in the Mexican war and in the war between the states came in large part from the Upper Mississippi field.

The literature of the area is abundant. In the first volume of the Worthen survey, in 1866 (31, pp. 153–207) is an early account; U.S.G.S. bulletins by Bain (32, 33) give a later description and the state survey bulletins (30, 34, 35) give more recent details. Topographic as well as geologic maps of the Galena-Elizabeth quadrangles in the bulletin by Trowbridge and Shaw cover the area.

Excellent specimens, particularly of galena crystals, were formerly plentiful from the openings in the Galena dolomite and while these museum specimens are no longer available, excellent laboratory material of both the lead and the zinc sulphides may still be obtained. Smithsonite, the zinc carbonate ore, may be had and the corresponding lead carbonate, cerusite, occurs as a coating on some of the galena specimens. Marcasite, generally partially oxided to the oxide, calcite and chert are abundant and easily found as well as excellent specimens of the dolomite country rock in both dense and crystalline form.

The region should be of particular interest to earth-science teachers

in the Chicago vicinity as the area is less than 175 miles from the Loop, and the trip may be made in a single day, better over a weekend, to allow time for collecting. Aside from the collecting possibilities, the geological features are also of interest. The lack of recent glacial drift, which surrounds the area, the outlying mounds as remnants of the escarpment, and the reversal of drainage (30, pp. 95–99) in the south fork of Apple River, with the resulting canyon at the state park of the same name, are but a few of the features of geologic value to teachers.

The glacial drift might well be listed as a sixth area for collection, particularly that of the Wisconsin glaciation. For laboratory specimens of many types of igneous rocks, as well as some varieties of meta-igneous, this drift is an easily accessible source as the gravel pits and boulders afford a diverse mixture for the selection of laboratory material.

In conclusion, Illinois has available a considerable variety of rocks and minerals suitable for the earth-science laboratory and the teacher who does not utilize the opportunity for field collecting is missing an important teaching technique as well as an intriguing avocation.

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ATOMIC ENERGY IN SCIENCE AND ITS SOCIAL IMPLICATIONS*

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Since 1945 we have been repeatedly told that we are living in an atomic age. Certainly the existence of atomic energy has been amply demonstrated in the form of the atomic bomb and it is doubtful if there is any well informed American who has not been subjected to a barrage of propaganda relative to the enormous potentiality of the bomb as an instrument of war. However, I would surmise that the average American is also quite ignorant of the significance of the term atomic *energy* and chooses to consider this term as synonymous with atomic bomb. It appears to me that one of the problems which education must prepare to meet is the overcoming of this narrow view of atomic energy so that the average citizen will become aware of the vast possibilities of atomic energy in the technological applications to medicine, power, research and related fields in which so much of a constructive nature can be accomplished for all mankind. I do not decry the military significance of the atomic bomb; I am merely asking that when we discuss atomic energy that we treat it as an energy problem and not consider only its effects on our social order as a weapon of war. Educators must recognize that the students of today will be exposed to many of the effects of atomic energy when it is perfected and adapted for use in the years to come. These students are entitled to have all phases of atomic energy presented to them and the possible social and economic effects on their daily lives should be indicated. We demand of our physicians that they be cognizant of the latest in medical techniques; we require our mechanics to be trained in the latest techniques of automobile repairing. It is probably not too much to expect that our schools are alert to current changes in the social order and that they are aware of the growing importance of atomic energy in the life of the American people. If we are concerned only from a financial point of view we must recognize that the United States Atomic Energy Commission is spending a good deal of the taxpayer's money each year. Where is it going and for what ultimate purposes? However, there are more compelling and interesting reasons for the inclusion of atomic energy in the school curriculum than just financial considerations and the ultimate concern of every progressive educator is the future welfare of the student. What can atomic energy do to improve the life of the American boy or girl?

* Presented at the 100th anniversary convention of the Norfolk County Teachers' Association, Secondary Section, Needham, Mass., October 28, 1949.

These are questions which the teacher should try and answer so that the future citizen will be somewhat informed as to the meaning and significance of this new discovery.

The problem for the educator of course arises when he attempts to determine *who* shall teach atomic energy, *what* shall be taught as properly belonging in the field of atomic energy and *how* this subject matter can be presented in the most efficient manner to the student. To date, it would seem from our work in the New England School Science Council that not one of these questions has a clear answer in the minds of many school administrators and teachers. Our committee was established in an attempt to find possible answers to these questions and what follows is the gist of what we have found out in the course of a year's work with secondary schools in New England and throughout the country. Incidentally, I might say that this problem is not peculiar to New England but will be found to be true all through the United States.

Who Shall Teach Atomic Energy

The science teacher has assumed the responsibility in most schools for presenting material on atomic energy. In part, this has probably arisen because the school administration has felt that the subject was a technical one and should be handled by the science department. It is true that there are technical phases of atomic energy which should be covered by the science faculty. The technical aspects include contributions from Physics, Chemistry and Biology and the facilities of the entire science department should be utilized in this connection. However, there is also a great deal of information which lies outside of the domain of pure science and which should be considered as belonging to the fields of the social sciences. Atomic energy will have a great effect on our social and economic order and it may necessitate changes in our governmental attitude. These are problems with which the science teacher would not feel competent to deal and it is for this reason that the social science faculty should be included in the teaching of atomic energy. In short, the problem of who shall teach atomic energy should not be interpreted in the narrow sense of technical terms but should be expanded to cover all the implications of the program particularly in the social order. The science teacher would welcome the assistance which his fellow teachers in the social fields could give and the student would benefit from the realization that this is not a laboratory problem but will have impact on his daily life.

What Shall be Taught

One of the greatest sources of difficulty among teachers in the

secondary schools of New England was to determine what material should be presented to students of that educational level. This was true of science teachers and even more so of social science teachers. A vast amount of material has been written on the subject of atomic energy but much of it, until recently, was not suitable for use at the secondary school level, and little of it was devoted to the social implications of atomic energy. After considerable work, our committee has succeeded in compiling a bibliography of source materials which lists well over 150 items. These items include not only books and periodicals but also audio-visual aids, equipment for demonstration purposes and sources of supply. There is material now available for those teachers who intend to teach atomic energy and the amount is increasing slowly. It is our experience that no one text will suffice for this problem. This may seem a handicap but actually it is not because the teacher is free to develop his own material and to adapt it to his particular group of students. Few teaching units are available in New England or elsewhere. Some have been attempted by teachers of our group and the outcomes have been good in some cases and not so good in others. We have reason to expect that on the second try this year better success will be achieved by all the teachers. The main point is to try something. Most of the teachers with whom we worked had little experience with this subject before undertaking our program and we feel they have made a good start. The students are definitely on your side and they will be interested and eager to investigate the subject matter. Capitalize on this attitude and you will have an opportunity to do some real pioneering in this field. It is not necessary to expend large sums for Geiger counters or to plan to visit complicated cyclotrons. These represent but the technical phase and while excellent facilities exist in metropolitan Boston in this aspect of atomic energy, do not overlook the work of the hospitals in the applications of atomic energy to the field of medicine. It is the social implications which will have the greatest significance in the future life of the student. For that reason, I urge the teachers of the social sciences to enter this field and to consider seriously their relationship to the entire teaching problem. Without the contribution of the social sciences, this problem of atomic energy is given only a superficial treatment.

How Shall the Subject Matter be Presented

Method is always an important factor in the presentation of a new subject. The goal of most teachers is the adoption of an efficient manner of teaching so that the maximum coverage of subject matter can be accomplished in the minimum of time. This is true of the teaching of atomic energy. Since it is a relatively new subject in the school

curriculum it has to be introduced in the manner of an experiment in some cases and all teachers are desirous of success in such a case. Thus the question of what is the best way to teach this subject is particularly pertinent here. Our committee sponsored a one day workshop last June at which demonstrations were given of the teaching of atomic energy at the secondary school level and the elementary school level. These demonstrations were not intended to be models but rather typical methods of classroom teaching which had been actually tried during the school year. These demonstrations included a "live class" on the technical phases of atomic energy by a senior class from a high school in Cambridge, Mass. Another featured wire recordings of actual classroom responses by 6th graders in a New Hampshire school who had been introduced to the problem by a faculty member of a state teachers college in New Hampshire. The third demonstration featured a school assembly program in a private girls' school in Boston in which students from the 3rd to 12th grades participated in a program devoted to technical and social aspects of atomic energy. The demonstrations had nothing in common as far ar method is concerned and yet it is believed that they all represented successful attempts to teach this subject. It would appear that any method is suitable if the teacher knows what he wants to teach and if he recognizes the limitations of his class. It was apparent from this demonstration that there are certain limits on the technical side which should not be exceeded with secondary school pupils. But it was also apparent from observing the actual students that they are interested and they exhibited a number of items which they had made in connection with their study and which would be very useful in presenting the subject matter, *i.e.*, one student had a very neat method of showing chain reactions with mouse traps in which the reactions took place in a vertical series of boxes rather than in the conventional horizontal arrangement. It is felt that the teacher should not rely on the text and that a reference library of source material is a necessity in this case. It should be pointed out that a great deal of this source material can be procured at a very nominal cost and a fair percentage without any charge at all. There should be coordination between the science department and the social science department with the end in view of understanding each other's problems and of defining the particular aspects of atomic energy which each shall attempt to cover. Indeed, it is this last feature which is perhaps the most important of all. This problem of atomic energy education is a problem for all the faculty and requires the mutual cooperation of all members. The chances for success of such a program will be largely determined by the extent to which each member from each department is allowed to participate. This participation

should result in a more balanced program from which the student can gain some understanding of the tremendous changes which are bound to result in our social order when the applications of atomic energy to technology become a reality.

A NEW APPROACH TO THE LECTURE-DEMONSTRATION

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Class lecture-demonstrations in Science can be made more meaningful for the high school pupils! That is, if the simple procedure herein outlined is followed.

The basis of the demonstration is the textbook.

Instead of having the pupils follow the demonstration from the laboratory guide, mimeographed sheets, or just by watching, have them follow the demonstration as an adjunct to their text.

Here is the procedure: (as used in my chemistry classes)

First, emphasize the fact that you are going to verify the information given in the text.

Second, arrange the steps in the demonstration to follow the descriptive reading in the textbook.

Third, as the demonstration proceeds call attention to the fact that you are verifying the statements in the text and that you are demonstrating them.

As the demonstration proceeds in chemistry, the laboratory methods of preparation can be shown; the physical properties exhibited; the chemical properties verified; and, of course, the identification tests given.

The exact steps in the demonstration can be altered for each type of Science.

Why this procedure?

Many high school students fail to see the connection between what they read in the text and what is shown them. They get a notion that the demonstrations are true experiments not verification exercises.

A lecture-demonstration conducted in the manner described also aids in improving the students' own laboratory work. It enables them to see their own work in a new light—they too are verifying what they have been reading about, not working with an unrelated set of ideas.

Try this suggested procedure—the odds are good that the results obtained will be impressive.

TEACHING OF CONSERVATION AT UNIVERSITY LEVEL*

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The United States has rather recently emerged from an era of complacent assumption that Nature's gifts to us can never be exhausted to one of the world's leaders in philosophical and experimental attack on problems of conservation. The awakening was slow and somewhat unique in its successive partial recognition of resources in need of conservation. It came about in the following order: forest—soil—wildlife—mineral and fuel resources—fish, and finally water, especially also the elusive ground water.

Out of this hazy, disjunct partial recognition that Nature is a unit, and that all the resources gradually disappear with use, came the awakening concern about our total resources and their importance to our national welfare. Accompanying well-planned conservation activities were and still are the harsh siren warnings of books written in a style which borders on pessimistic fatalism.

Magazines and newspapers carried the echo of conservation work to the masses, many organizations inserted some "plank" on conservation into their program, even the CIO of some areas is toying with the topic of the day, conservation. Conservation carried information of sufficient human interest to be included in university catlaogs. A decade ago only a few universities offered work in this field, to-day every university lists one or more courses dealing with problems of conservation. It has been introduced into the high school curriculum, and at present it has made an important place for itself in the science program of the grades. Conservation camps were developed, and two years ago Indiana made some conservation course mandatory for all prospective high school teachers.

The Procedure at University Level

In university courses there are two approaches, i.e. the classroom and the camp. The classroom courses are again of two types. One leans heavily on lectures, augmented by some field trips, visual aids and student reports on current literature. This is the plan I follow at Butler University, where the subject is offered as a late afternoon and evening class. The other approach combines some field and indoor laboratory experiences. Of this latter type Prof. H. Michaud's course (Purdue University) is representative.

* The subject matter of this paper was presented as part of a symposium before the Conservation Group of CASMT at the 1949 Chicago convention.

This is publication 217 of the Botany Laboratory of Butler University.

In my estimation a conservation course is by its very nature different from typical science courses. It is all-inclusive, it is broad and extensive, dealing with areas and materials which could not possibly all be brought into the personal observation of members of a class. This necessitates bringing these vast resources to the student's attention by means of visual aids. Involved are various vegetation groups, grasslands as well as forests of greatly different composition, mining operations, ocean and great lakes fisheries, etc.

The conservation camp offers, perhaps, the best approach to the teaching of conservation. However, even here the visual aid must substitute for the field trips and other personas contacts to bring the vast resources which lie beyond the immediate home surroundings to the attention of the class.

A very successful camp is the Purdue-Department of Education camp which has been conducted during the past three summers by Professor H. H. Michaud of Purdue University at the Versailles State Park in Indiana. Briefly the course includes the following:

1. Objective for teaching conservation.
2. Soils and water conservation
3. Plant and animal taxonomy
   a. Methods of collecting and preserving
   b. Methods of identification
4. Plant ecology as it relates to conservation
   a. Method of study
   b. Contribution to land management
5. Animal ecology
   a. Methods of study
   b. Contributions to wild life management and control
6. Entomology
   a. Methods of collecting and studying insects
   b. Relation of insects to conservation
7. Forest conservation
   a. Methods of studying forests
   b. Identification of trees, forest values, and forest economics
8. Wildlife conservation and management
9. Fisheries and management
10. Plot studies for conservation practices
11. Curriculum planning
12. Related subject fields (to be treated by special lecturers)
    a. Geology and soil genesis.
    b. Health and nutrition
    c. General conservation philosophy
    d. Land economics
    e. Social values

f. Recreational values
g. Human values

The significant value of camp work is that experiences are as much as possible gained from observation and studies in the field.

For university campus classes one usually follows a text such as Gustafson *et al.*, or Parkins and Whitaker, which direct attention to and discuss in detail the following broad fields: History of conservation in the United States, soil (origin, erosion, conservation), water, forests, grasslands, parks, both national and state, wildlife (fish, game, fur animals), the web of life, mineral resources, both metal and fuel minerals. In some books one or all of the following important chapters are missing: The Problems of our Large Cities, Human Resources, Our Highways and Part They Play in Water Runoff, Stream Pollution.

It is my opinion that at university level it is not sufficient merely to bring again only a discussion of the resources as such but that there should be some consideration paid to the great laws which are involved in the production of such resources. The chapter on coal and oil should no doubt be introduced by a brief history of the geological time table, and placement of the Carboniferous era in this table. Also, the plant life which played the major part in formation of coal, as well as the theories on the origin of coal beds should be studied. The chapter on soil should include a discussion of the types of rocks and their significance in the formation of types of soils. The weathering agents deserve some special attention, especially the glaciers and how they work. Included should, perhaps, also be a survey of the geological phenomena which were instrumental in production of the physiography of the state. Forests are best understood if they are placed into the dynamics of succession and the part they played in forest migration and replacement during post-glacial times.

In my opinion teaching of conservation has experienced the same defects which are encumbent on the curricula of our biological sciences, i.e., the three levels (grades, high school, college) are not in the plans of makers of curricula or of textbook writers. Each level is developed independently as if it were terminating, and so the progressive aspect of the work is wanting. This has resulted in a diluted coverage of the whole of all fields in grades and high schools, the two frequently using identical subject matter and illustrative examples. The modern high school and even grade school texts bear this out. We are in an era of encyclopedic presentation in high school texts which have attempted to cover "just everything." I hope the day will soon come where we will apply conservation in our three levels of education in science teaching, and follow the example of the

modern languages where college need not repeat subject matter because grades and high school attempted to drain the subject matter dry, instead of covering a smaller amount thoroughly. I have found the same difficulty in selecting visual aids. Good films have wandered through the classrooms of grades and high schools, perhaps the same in both, leaving little specifically for the university student. For that reason it is essential that in a university course an instructor find out first whether or not a certain film has been seen by the majority of a class while they were in high school. This is good conservation from several angles.

Most or all textbooks on conservation seem to fail in presenting first of all the fundamental basis of all conservation, i.e. a recognition that conservation based on selfish "personal reward expectation" will never lead anywhere. So to-day we hear promises of more fish, more ducks, more recreation, more income from bigger crops, cheaper wood, etc. as a reward for good conservation methods. Conservation based on such selfish interests cannot succeed because it ignores a recognition of the stewardship of things given to HUMANITY, not to anyone personally. For that reason my course is introduced with a discussion of the fundamental basis of all conservation, i.e. an unselfish tolerance towards LIFE and respect for the value of things. Such a psychology of conservation involves the following factors:

1. Knowledge of scientific laws and truths
2. Tolerance towards all of life
3. Selfishness, or attitude towards fellow men
4. Attitude towards "values,"
   a. Respect for things, both living and mechanical
   b. Economic value
   c. Esthetic value
5. Factors which militate against proper attitudes towards values
   a. Ignorance of governing scientific laws
   b. Poor management
   c. Carelessness
   d. Lack of proper attitude towards the "business of living"
   e. Spirit of vandalism
6. Scope of application
   a. Private property
   b. The neighbor's property
   c. Community and governmental property

In all our teaching efforts it is most important that the applied phase of the work be stressed. The most important training agent is still the home, and our efforts may because of counteracting home influence not show great progress in the applied phase in the lives of our students. That should not discourage us but rather remind the

teacher that ours is a crusader's cause which knows no discouragement.

It is my opinion that conservation teaching should not leave students with the hope that conservation of the world's resources will insure indefinitely abundance of all gifts of Nature for all people, or even for citizens of one nation, it will not do this. All that it can do is extend use of these gifts over a longer period of time and thus serve more generations of men. Forest primeval, coal, oil, iron, etc. will not last forever, some day they will be exhausted, in spite of all conservation practices. However, the more slowly that day is approached the more opportunity will be given the inventive genius of man to fit himself into such a new world order while the economic status is still sufficiently favorable to permit his carrying out the necessary investigations to discover substitutes, methods of tapping new sources of power, etc.

Thus let us face the problems in their entirety, those of our own small span of life and those projected into the future, and live and plan accordingly with confidence in the discoveries of science and in the proposals of governmental agencies. Live and work with optimism and understanding, not with pessimism and dispair. During the past great war we were denied many agreeable accessories, we fitted ourselves into the modifications and enjoyed the lesser things with greater and deeper understanding. If necessary, we can do so even in times of peace. Perhaps we are, as a friend of mine said, "suffering prosperity," and in the process have become encrusted with selfishness which shuts out the true concept of "live and let live."

CONFERENCE ON THE TEACHING OF MATHEMATICS
(ARITHMETIC AND SECONDARY)

ILLINOIS STATE NORMAL UNIVERSITY
Saturday, April 22, 1950—9 A.M.–3 P.M.

Speakers: Professor Leo J. Brueckner, Univ. of Minn.
Professor F. L. Wren, George Peabody College, Tenn.

Group discussions for both Elementary and Secondary Teachers.

C. N. MILLS
Head Math. Dept.

That educators are active in service organizations as well as in school work is seen, for example, in the fact that 15 American educators—college presidents, professors, superintendents, principals and other administrators—are among the 1949–50 committeemen and district governors of Rotary International, world-wide service organization.

NEA Journal

DESIGNING SCIENCE COURSES FOR GENERAL EDUCATION ON THE COLLEGE LEVEL*

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Antioch College, Yellow Springs, Ohio

Specialization has been described as "knowing more and more about less and less." By extrapolation the joke can be pushed as far as it can go, to "knowing everything about nothing!" In this same vein, generalization might be described as "knowing less and less about more and more." And the reciprocal consequence becomes, of course, "knowing nothing about everything"! It would be hard if we were required to choose between two such indistinguishably futile extremes. And so it is possible to make both mistakes at once in designing the college curriculum and to graduate narrow specialists who remain uncreative—however routinely competent—in their fields and who prove, outside their fields, to be generally ineffective. Perhaps the single most damaging error a faculty can make is to set the apparently ambitious objective of *completing* the education of the student, general and field, by the time he receives his terminal certificate or degree. In my judgment, this error interferes drastically with the achievement of any good objective they might otherwise be approaching.

Now both specialization and generalization are essential attributes of the citizen in the modern world. At Antioch College, they are accepted as supplementary objectives of a liberal education. Peak achievement in an area of special competence is regarded as a necessary feature in the profile of the symmetrical individual. On the other hand, accepting as we do the responsibility of educating the whole person, we are attempting to weight equivalently, to revise continuously, and to integrate significantly the three identifiable components in our curriculum: academic courses, work experiences in diverse communities, and processes of self-government whereby we seek to improve our way of life in the college community itself. In each of these, we expect a participant to demonstrate both specialized and generalized achievement. And the beginning of curricular wisdom is proving to be our acceptance of the apparently modest objective of assisting the student to the recognition of his education as a permanent responsibility of his own, so that he is both enthusiastic and skillful about continuing both his professionalization and his general education as long as he lives. The better to encourage this, the Antioch curriculum is so designed that field courses and general required courses extend in parallel throughout the college years.

* Read at the Junior College Group Meeting of the Central Association of Science and Mathematics Teachers, November 26, 1949.

To focus for a moment on elementary science courses—whether offered to those planning careers in science or offered to those expecting to remain laymen in science—it would seem that the easiest error to make is to design and teach *survey* courses. They may be given on two different levels—without and with mathematical emphasis—but survey courses they are apt to be none the less. They can be so recognized by their compilation of too many topics to be "covered" and by a consequent superficiality in learning, however deceptively rigorous the teaching is intended to be. Not the least refreshing aspect of the "block-and-gap" course designed at Princeton by Eric Rogers is his listing in the syllabus of *two* tables of contents. One, the briefer, shows those topics that are included. The other, the much longer, shows those topics that are excluded. Together, the two lists add up to the table of contents of the typical survey course, of the standard text!

The scientist-in-training, conventionally taught, discovers very soon that he has not mastered what he covered in the introductory courses. Instead, he has to learn each part of the general course as he encounters it on the advanced level. The layman, survey-taught, discovers very soon that he retains little of what he presumably covered. He may in good faith have submitted to a process that promised to equip him with "the fundamentals," somehow defined for the layman. The fragile assumptions seem to be: (i) sometime he may need to apply a fundamental; (ii) he will then recognize that he needs to; (iii) he will still have the needed fundamental; (iv) he will know how to apply it!

In short, the typical introductory technical course makes the mistake of attempting to cover all the fundamentals that might possibly be prerequisites to later, advanced courses. The typical general course in science attempts to cover all the fundamentals that the layman will need to know as he encounters problems in the years that follow. If we define, instead, the central objective to be the production of a person—not educated, but—more self-educable, then the first principle for the design of the course we teach is this: ***we must prefer to exclude rather than to include too much of the conventional content of such a course!*** Let me testify! Each year I teach less but I have convincing evidence that my students learn more!

As to what should be excluded and what included, I think that there is a sense in which it could be properly argued that it makes very little difference. I surely do not think that the content can be specified at any such working conference as this for classrooms throughout the Central Region. No doubt, the organizers of introductory technical courses would find agreement more easily than organizers of courses for the layman in science. Their objectives are

more focussed and the structure of any scientific field indicates certain strategic problems for initial mastery. But even here there will be enough differences among successful courses to support the rather daring principle that ***what is excluded and what is included are not of crucial importance.***

When we turn to science courses in general education, perhaps we can simply assert that the limited content can be selected only in terms of the specific students, the specific teachers, the specific year, and the specific community within which the learning occurs. What is included should meet certain requirements, among which can be specified the following: (i) the participants must become genuinely involved in a learning experience that challenges them; (ii) they must come to recognize the problem to be real, interesting and significant —to cite J. D. Bernal's criteria; (iii) the project must make good use of the available resources, including the interests and abilities of the teachers.

In everything argued to this point, something far more significant than content is suggested. Let me identify it as the ***quality*** of the teaching and learning processes. And let me immediately shift the focus of this paper to this more significant consideration. From this point on, I shall limit my argument to science courses designed for purposes of general education.

Let me promptly turn, then, to these ***purposes*** of general education—or rather to a few of them. For the sake of economy, I shall arbitrarily select the list of objectives defined in 1947 by the President's Commission on Higher Education and reported in the document, *Higher Education for American Deomocracy—Volume I: Establishing the Goals.* There were eleven objectives stated and they interpenetrate so that isolating only three of them is not wholly justifiable. However, consider these three.

> "1. To develop for the regulation of one's personal and civic life a code of behavior based on ethical principles consistent with democratic ideals.
> 4. . . . to apply habits of scientific thought to both personal and civic problems . . . .
> 11. To acquire and use the skills and habits involved in critical and constructive thinking."

The Physical Science Work Group at the March, 1949 Conference on Building a Program of General Education, held at the University of Minnesota, considered these objectives—along with many other matters—and came out with nine specific proposals, one of which I select to quote:

> "6. That studies should be initiated to determine how far habits of scientific thought, which constitute one important objective of present physical science courses, can be transferred to personal and civic problems."

Our Work Group was informed by an expert in educational research that "200 studies have shown that transfer left to chance does not occur"! We therefore inaugurated a project, still in its infancy, which I should like to describe for you.

Each of us in the Work Group agreed to confer with colleagues representing the other areas in his own institution, to determine what material should be included in the physical science courses—and, reciprocally, in the other courses—with a view to better integration. The next and latest step taken by the small coordinating committee set up to administer this project, on discovering possible reciprocal services among various courses in general education, has consisted of a letter of reminder to each participant, from which I quote:

"The project grew out of the following considerations:

1. There has been a widespread feeling, both among science and non-science teachers, that one of the primary objectives of science courses in general education should be that of 'coaching' the student in the 'scientific method' with the idea that he would then have a powerful tool to apply to the solution of all kinds of practical problems.
2. As science teachers have tried to do this, it has become more and more apparent that the scientific method is not a panacean formula, and that the methods used by scientists often have in common only those elements which make these methods non-applicable to non-scientific problems.
3. There has been a growing body of evidence that even if students could learn a scientific method by studying the work of scientists, they would not transfer this method to problems in other areas without specifically being shown how to do it. In other words, the transfer of the method would have to constitute a major part of the study in science courses.
4. Science teachers do not wish to make the transfer a major part of their course material, and they do not feel qualified to make the applications even to branches of science other than their own, let alone to other areas such as the social sciences, the arts, and the humanities.

These considerations have given rise to a suspicion that the contribution which science teaching should make to the well-rounded general education of the individual has not been properly evaluated. Furthermore, most science teachers who are themselves products of a narrow specialized education are not capable of making this evaluation without help.

It was decided, therefore, that the science teachers should seek this help from a 'composite educated man' composed of their colleagues in all other fields of knowledge, by asking these colleagues questions which would discover what contributions they think science courses *should* make . . . .

The committee conceives of the project as a long term study which will involve many unsuccessful first tries . . . by a process of successive approximations we hope to arrive at a clearer conception of our role as participants in a broad general education program . . . ."

I am earnestly interested in this project and have described it as fully as I have, partly for the reason that we need any assistance that we can elicit. Perhaps some of you will volunteer to participate. But my other reasons are directly relevant to the development of my argument in this paper. I wish to pick up two points made in the above letter, to develop further: (i) "transfer of the method would

have to be a major part of the study in courses in general education"; (ii) "science teachers do not feel qualified."

I have come, therefore, to propose a simple yet drastic break with academic convention. I advocate the setting up of experiments in which intensive general education courses be administered by panels of teachers representative of the divisions of the curriculum, for the purpose of developing and practicing methods of problem-solving that meet rigorously both scientific and democratic criteria. I have even sorted out several different courses which together might comprise the core of the general component in the curriculum.

All of these integrated courses would be not only panel-guided but vigilantly kept "on the beam" of genuine inquiry. This would follow the more probably if a requirement were set up excluding any teacher who "known the answers" to the problems investigated, who wishes to convey his own or someone's analysis or to demonstrate that problems are essentially insoluble. The teaching and learning processes would be—without subterfuge—democratic and scientific. Superficialty would be avoided by using the case-study approach and by not hurrying from a problem before it has yielded convincingly to the inquiry. Active participation would be sought by organizing a division of labor that would exact necessary and unduplicable contributions from each participant. The panel members would be first of all teachers, fellow-learners, willing to submit on the same terms as the students to the self-imposed disciplines of the enterprise, able to give and receive criticism, capable of controversy with educational objectives always in the center of their attention. They would of course be laymen in almost everything, specialists only in their fields. The physical scientist, then,—to use an example—would be, except by rare coincidence, no authority on a matter of physical science but perhaps specially skilled in two ways: (i) in locating an adequate authority in any instance from among his colleagues or from the wider world or in the literature; (ii) in facilitating communication between such an authority and the laymen with whom he is learning. The mechanics of the course, while flexible and imaginatively refined, would emphasize, as the most frequently assembled working group, a small committee—small enough for intimate and friendly relations to develop among its members and for individual counseling and other services to be continuously available.

Neither integration nor transfer would be left to chance. They would be persistently achieved. The experience would be unduplicable enough to be judged good for all students—should we add, for all teachers? For the resolute purpose would be the refining and demonstrating of scientific and democratic problem-solving processes. The most significant evaluation device would be the collection of

evidence that those who have participated in the experiment continue it thereafter, wherever they go, beyond the college years, as they seek to continue their education and to make their appropriate contribution, in other communities, with other associates, to the solving of problems.

I spent my graduate years attempting to identify "the science that a citizen needs to know," what I sometimes called the "basic scientific literacy required by the modern era." My conviction grew that only in some such experiment as I have here proposed can one find out what science—subject matter or method—is relevant to each particular issue.

Now that I am involved in the redesign of science courses and, more broadly, of the general education curriculum, I have come to advocate that a succession of such integrated courses constitute the required, continuous core of the general education curriculum. The courses that most of us have hitherto designed should, then, become electives for college undergraduates or, better still, for adults from the wider community to join, whenever they are motivated to focus on some science, abstracted as it is, for the most part, from the lives of people in communities, facing problems.

Very briefly indeed, four courses that I have isolated as worth considering for inclusion in this integrated, problem solving core are: (i) a course including the orientation and other services of the college, directed always to the personal-social needs of specific maturing adolescents; (ii) a course illuminating the development of the "one world community," affording orientation in space and time, but avoiding superficiality by concentrating intensively upon this particular culture or that significant transitional period in human history; (iii) a course investigating ***one or two*** crucial contemporary issues; and (iv) a course for developing and trying out processes whereby a community can be assisted to become really a good community, united in democratic planning and action toward improving its way of life. This culminating course would require a new relationship between the college and its environs. It suggests a particularly challenging opportunity for the junior college or community college now being instituted in several states.

We have, perhaps, none of us experienced the sort of thing I advocate. I confess that I have not. We speak of rigorous inquiry, of integrating our learning, of the power of democratic and scientific procedures, and the like. But how many of us have worked hard and long and rewardingly, with collaboration, in the analysis of a single, crucial contemporary issue to the point where it began to resolve convincingly? We do not educate very differently than we have been educated. Who was it that asked: "who is to educate the educators"?

The salvation in cultural innovation is that men *can* invent something significantly though only partly new, that teachers *can* become learners in programs superior to any they have known. No small part of my enthusiasm for what I propose is that it would give me and my colleagues an extraordinary chance for professional growth. Let me quote from an important article* in which Joseph Schwab of the University of Chicago has outlined the objectives and techniques of the science for general education courses in his curriculum. He concludes:

"Such materials require men trained to teach them. Ideally, the faculty of a liberal program can be expected to possess disciplines beyond the ones learned in their profession, but practically they will come to possess them only by participation in courses which require and evoke them and which are manned in the first instance by teachers who have them already . . . . (This) would create a situation in which . . . each staff member would be undergoing the same liberal training intended for the students. And liberal training is infectious."

We sometimes acknowledge that education is supposed to affect the participants, teachers and students, profoundly—to stir them, to change them significantly, not only intellectually but morally as well. A sensitive discussion of the educational difficulty of this task can be found in J. Robert Oppenheimer's lecture last year at the Massachusetts Institute of Technology. His concern was with the training of the physicist, but much of what he said is as relevant to the teacher of science in general education. How can one become indelibly impressed with the spirit of science? He contended that "it is very different to hear the results of science, as they may be descriptively or even analytically taught . . . and to participate even in a modest way in the actual attainment of new knowledge." He suggested that "the teaching of science is at its best when it is most like an apprenticeship" for "there is something irreversible about acquiring knowledge; and the simulation of the search for it differs in a most profound way from the reality."

I have proposed a series of integrated courses which might well meet some of these exacting requirements. They might well provide "apprenticeship" for all participants, students and teachers. They might well "impress us indelibly with the spirit of democracy and of science." They might well give us the satisfaction of "participating even in a modest way in the actual attainment of new knowledge" as we investigate problems still unsolved.

To face this problem squarely will exact painful labor from any of us—more painful than most of us could sustain without support from associates who are men of good will. But to attempt less may

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* Schwab, Joseph J., "The Nature of Scientific Knowledge as Related to Liberal Education," *The Journal of General Education*, Vol. III, No. 4, July, 1949.

well be to abdicate our high calling, perhaps fatally. The reward for our labors may be a decisive, however modest, contribution to human survival, even more—to the genuine renaissance of culture that will follow from and justify human survival.

REPORT OF THE CASMT NOVEMBER MEETING

Elementary School Group

The meeting of the Elementary School Group of the Central Association of Science and Mathematics Teachers held Saturday morning, November 26 at the Edgewater Beach Hotel opened with opportunity for all attending to view various exhibits of children's work from National College of Education, Oak Park, Kenilworth, Winnetka and Waukegan Public Schools. Portable cases from the Chicago Museum of Natural History portrayed materials for teacher use. Those who attended were vitally interested in the topic: "How Can Science Be Made an Integral Part of the Elementary School Program?" The panel consisted of L. W. Miller, Illinois State Normal University, Normal, Illinois, H. Emmett Brown, New York State Teachers College at Buffalo, Elsa Meder, Houghton-Mifflin Company, Boston, Margaret Waters, Oak Park Public Schools, Marie Svoboda, Chicago Museum of Natural History, Helen Schmidt, Winnetka Public Schools, with Dr. Bingham of Northwestern University and Dr. Wilbur Beauchamp of the University of Chicago as summarizer. From an overview of what science in the elementary school is, panel members discussed:

How can every-day happenings provide opportunities for observation and discovery?
How do activities in science help to meet the basic needs of children?
How does science contribute to the social life of the child?
In what ways should science come into the elementary school curriculum?

In summary it was agreed that the central thought of the entire discussion was that science is a method of behavior concerned with bringing about changes in the way children think, rather than a succession of predigested answers. The major task of the teacher is one of arranging situations in which thinking is the method of learning. This may start with incidents in a child's life where he asks why and how. The teacher then must help children plan ways of answering their questions. Later they come to generalizations through these experiences. Scientific thinking may be no different than the critical thinking we do as adults, but it has to be taught.

Science may come into the curriculum from incidental situations arising from immediate interest and of short duration. Experiences may be sequential, that is, a series of related ones which may lead to the development of one or more basic concepts. There is also the science unit, an organized sequential series of planned experiences, and other integrative experiences where science is just one phase of a large unit of work. The more nearly we approximate the needs of children, the more enduring will science be in the curriculum.

N. E. Bingham, *Chairman*

Electric deodorizer, suitable for use in the kitchen or anywhere in the house to kill household odors, is a simple unit which is plugged directly into the ordinary electric outlet. A built-in heating unit activates enclosed deodorizing ingredients, releasing them into the room.

ARGUMENTS AGAINST UNIVERSAL ADOPTION OF THE METRIC SYSTEM

CECIL B. READ
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The use of the metric system of measurement is quite generally accepted in scientific work. From time to time the question is raised: Why do we not use the metric system for all purposes, instead of largely restricting its use to certain fields? Agitation for such universal use seems to increase at intervals, at which times periodicals and books carry considerable material on the subject. For example, about a quarter of a century ago a bill which was being considered in Congress resulted in the publication of much discussion of the subject.

The recent publication of the Twentieth Yearbook of the National Council of Teachers of Mathematics makes available a very good description of and history of the metric system, and gives in excellent form the decided advantages which would accrue if the system were universally adopted; together with an impressive list of individuals, firms, and organizations which favor such general adoption. It would be absurd for any single individual to attempt to improve upon this splendid presentation. There is however, one disturbing thought: With all these advantages, with this impressive group advocating a change, why has not the change taken place? The arguments for universal adoption are strikingly presented—are there no valid arguments on the other side? What does the attorney for the defense have to say?

Irrespective of how strongly one may feel toward one side of a question, it cannot be said that one has arrived at a conclusion by scientific means until there has been careful consideration of all factors and analysis of arguments on both sides. The scientist does not need to be informed of many of the advantages of the metric system; he does need to know the arguments which may be advanced against it. It is with this in mind that an attempt has been made to present some of the arguments which are frequently advanced *against* universal adoption of the metric system. Obviously in the space available it would be impossible to present arguments in complete detail or to give extensive lists of individuals or organizations taking the viewpoint presented. Extensive discussion will be found in some of the references in the bibliography. In particular it may be of value to examine arguments pro and con which were advanced some twenty years ago—the passage of time may indicate to the present day scientific reader something of their validity as tested by time.

Above all, it must not be considered that either the author or SCHOOL SCIENCE AND MATHEMATICS is arguing against the universal adoption of the metric system. There has been excellent presentation of one side of the discussion in the Twentieth Yearbook mentioned—the purpose here is to make available to those interested some of the arguments on the other side, without comment as to the merits of the points presented, but rather with the idea of helping one arrive at a scientific conclusion. Some arguments often presented on either side of this issue are obviously weak and can readily be refuted, others are of much greater merit. Unfortunately, published articles on both sides of the question often show evidence of prejudice or unwillingness to see any merit in the other side, and are sometimes filled with petty bickering and name-calling.

In the presentation of this material, the arguments have been classified into some half dozen broad categories—the division is frankly arbitrary, and some arguments could well be placed in a different group.

I. *The metric system does not possess sufficient merit to insure its adoption without compulsory legislation.* Since the year 1866, it has been in the United States *permissible* for all who wish to do so to use the metric system. This permissive law does not seem to meet with the approval of proponents of the metric system. They appear to wish, to varying degrees, some *mandatory* method providing for exclusive use of the metric system. If the benefits of the system, as contrasted with the English system, are all that is claimed, where has the common sense of the American business man been the last eighty years? It would appear that the merits of the metric system have not been marked enough to overcome our liking for the habitual; perhaps the American people do and would resent compulsion—a practice contrary to the normal trend of development in a free society. When the metric system was made permissive, some thought that the power of the schools would soon make this country wholly metric—the expected result has not materialized.

The argument is often presented that the merit of the metric system is apparent in the fact that such a large number of countries have passed compulsory legislation requiring its use. When the better comparisons of population involved, wealth of the countries, and volume of industrial production, are made, the case becomes much less impressive, in fact the balance swings to the side of the British system.

The report of the Academy of Sciences in 1792, the basis of the metric system, was adopted by a legislative assembly as presented, without debate, in spite of the fact that the specific value of no unit

was indicated, and no one knew whether or not these were convenient trade units.

It is often assumed that the adoption of the metric system is easy and the transition period short, hence the system rapidly comes into full use in countries that have authorized it. The fallacy of the argument is apparent if we consider countries like Great Britain and the United States where the law is simply permissive. Moreover, in other countries in whatever extent the system is used in trade or commerce, such use is due to compulsion.

English speaking peoples refuse to become slaves to a theory or to submit to the tyranny of a decimal sub-division. They have continued to use the almost instinctive subdivisions—halves, quarters, etc., but on the other hand they have adopted decimal subdivisions and metric units where and only where these have been found more convenient. There is often reason behind tradition, the present system which allows a selection of alternatives is valuable. For example, despite the fact that electrical science may be taught and experiments conducted in the metric system, the English units are almost exclusively used in practical applications. This is merely one example of the fact that users of measurement, with free choice, may not always select what some theoretical scientist thinks is the best system. The outlook of the scientist is often limited—other views should not be overlooked. Perhaps many people subconsciously resist the view that the scientist is always right.

II. *Even compulsory legislation will not eliminate the present system.* It is often stated that no country, once having adopted the metric system, has ever returned to its old system. The statement, while true for any country as a whole, overlooks the fact (important when we consider the United States) that during World War I the United States Army adopted the use of the metric system, but following the conclusion of the war, after careful consideration, it abandoned such use. It is likewise true that the Intercollegiate Association of Amateur Athletes of America (the I.C.A.A.A.A.) passed rules requiring the use of the metric system, then later decided to return to the English units for all but outdoor track events.

A recent summary shows that in continental Europe and in South America the most customary units in trade and industry are the inch, the pound, and the foot. In South America, next to these are the *arroba* and the *palma*. That is, in spite of legal compulsion, the result has been a mixed system, confusion in thinking, useless labor in calculation and conversion, disregard and evasion of the laws. In fact, the French government is still seeking effective measures to secure the use of metric units and the displacement of old units.

In view of the way that national pride has influenced legislation, one might consider that if the metric system had been called the "French" system and what is called by some the "English" system had been known as the "pound-yard" system, we might have fewer countries with the compulsory metric system and more with the "pound-yard" system.

III. *The metric system is not by any means perfect, nor is the English system completely bad.* Not one base unit in the metric system corresponds to its original definition. The argument that the metre is a unit in nature vanished when officially abandoned by the French government in 1869. It is not the 1/10,000,000 part of a meridian quadrant, it is the distance between two marks on a bar. The possibility of determining linear distances in terms of wave length of light deprived the metric system of any apparent superiority (once so widely claimed) it may have possessed over other standards because of the facility with which it could be reproduced. In fact, one cubic centimeter of water does not weigh one gram; and even in the one field where it might be of use to know that a liter of water weighs a kilogram—naval architecture—it fails because of the increased density of sea water.

In stressing the simplicity of computation with the metric system, it needs to be remembered that in engineering calculations, cubic contents have to be multiplied by irregular numbers representing specific gravities. The multipliers are as simple in the English system as in the metric. Moreover, mere convenient in scientific computation is not sufficient reason to upset a traditional system which has evolved out of the practical needs of everyday life. The English system of subdivision, such as yards, feet, and inches; pounds and ounces; and the like, makes for quicker perception. We are prone to overlook the convenient size of the fundamental units of the English system. The centimeter is too small for rough calculations in which we employ the inch, the millimeter is too large for exact measurements. The great bulk of machine tooling requires units between 0.1 mm. and 0.01 mm. The one is too coarse, the other too fine. As a result, we resort to halving and quartering of millimeters—the virtue of a decimal system fails by the forced use of common fractions. A survey of engineering drawings and data shows that in general, it is necessary to use one more digit when metric measurement is involved. No one can deny the greater ease of perception of a one digit number as compared with a two digit number, and so on. In fact, not a single metric unit owes its existence to the fact that it is particularly adapted to any practical measuring use. The term "world pound" applied to the half kilogram is indicative of the unsuitability of the kilogram.

The fact that under the law of one state the weight of a bushel of potatoes is 60 pounds, while in other states it is 57 pounds is not a defect of the English system, for the same difference could exist under the metric or any other system.

Decimal dimensioning affords all the major benefits of the metric system without the manifold problems of conversion. We have already eliminated many of the troubles of the English system by decimalizing at key points and by dropping intermediate measures. All are familiar with measurement in decimal parts of an inch; fabric dealers use yards and inches, eliminating feet; most of use feet and miles, eliminating yards, rods, and furlongs.

In spite of the vaunted excellence of the metric system and claimed defects of the English system, it might be noted that practically all navigation is carried out in the English system, or that the Fahrenheit thermometer, often criticized as without any scientific basis, has been described as "almost perfect" for human purposes.* Again, even with the metric system standards in one country are not the same as in another—the metre in Berlin is not the same as the metre in Paris. Foreign standards for metric screw threads vary from nation to nation, and pitches are expressed in half and quarter millimeters. Again it is stressed that the human mind needs handy units, of a size such that the number of units is not excessively high. In French and German engineering, the centimeter is never used as a unit of length —not even a continental chemist asks for his liquor in cubic centimeters.

If a change is to be made, we might well consider a change, not much more radical in nature, to a number system based on 12. The duodecimal system has essentially all of the advantages of the decimal system, and many more, and in addition, lacks some of the disadvantages. Again, it might be suggested that if the so-called metric countries would adopt the yard as the length of the metre, and two pounds as the weight of their kilogram, a useful universal system would result without much sacrifice.

IV. *The problem of education would not be simplified, but made more complex.* The English names of the units, words of one syllable, differ in sound sufficiently to make them distinct, as compared with the polysyllabic names of the metric units which are quite similar in sound and readily confused.

Every adult would need to be educated to think in the new units. Obviously clerks and bookkeepers would need not only to become familiar with a new system, but would need special training in com-

* Brooks, Charles F., The Metric System in Meteorology, in the Twentieth Yearbook of the National Council of Teachers of Mathematics, p. 67.

putation. The consumer is not accustomed to thinking in such units, and with a considerable portion of our population, fraudulent practices might be made easier. For example, ask your friends whether sirloin steak is cheap at \$1.10 per kilogram. Is Iowa farm land cheap at \$50 per hectare?

For at least a generation children would have to learn both systems and conversion factors. Actually the learning of weights and measures would be more difficult for even with compulsion a mixed system results, with the necessity of learning conversion factors as well as additional units. If we will recall that as late as 1845 there were many problems in our arithmetic books relating to the conversion of the currencies of the various states and to conversion into federal money, we can see what a problem of education would be added to the crowded curriculum in arithmetic.

The often claimed simplicity in computation is not valid when existing units must be expressed in equivalent metric units. A building lot, now in existence, measuring 25 by 100 feet, is readily seen to contain 2500 square feet. It could, under a metric system, be described as 7.6002 metres by 30.48006 metres. Certainly the computation of its area is not simplified. Almost every quoted example illustrating the simplicity of the metric system involves the weight of a volume of water. If the substance is other than water, the specific gravity factor makes the advantage no longer so marked. One wonders whether advocates of the metric system are really interested in a scientific evaluation of the merits of the two systems, or in the most effective presentation of one side of the question.

V. *The expense involved in the change to a metric system would be prohibitive.* This is always a painful subject to those urging a change. Although this argument is one of the last presented in this article, it is by no means least.

The fact is often overlooked that France, Germany, and other countries changed to a metric system before their industrial life was organized and systematized, without many of the problems which exist in a complex industrial organization such as we now have.

The investment in designs, drawings, gages, dies and tools made and standardized according to the English system is enormous. Many manufacturers claim expense in excess of a million dollars would be required for their firm to change to metric units. In 1920 the Cleveland Chamber of Commerce, in its report against the adoption of the metric system gave detailed estimates of the cost of such a change. One concern alone estimated a cost of \$380,965 in addition to annual expenditures of about \$93,000. Representatives of metal working industries, carrying measurements to limits as small as 0.0001 inch

claim they see no practical interchangeable method of converting to the metric system.

Replacement parts on machines and equipment would, if constructed to metric units, not interchange with existing parts. A single example is given—the 12 pitch gear. The closest pitch in the metric system is module 2. These gears will not run together because of differences in thickness of the teeth. To run such gears together it would be necessary to change the 2 module to 1.889 module, or our standard to 2 module. Millions of gears now on hand would no longer be interchangeable; all existing gear cutters would have to be rebuilt, and the present gages used for checking would be of no value except possibly in repairing old gearing. Such an example could be multiplied by the hundred. Since replacement parts would not interchange, for a long period of years all stocks of repair parts would have to be doubled, involving a needless expense in invested capital. For example, think of the many plumbing installations which could not be repaired if pipe sizes had to be metrical. Consider a single pipe connection—a $\frac{1}{2}$ inch tee in a $\frac{3}{4}$ inch line. At present, one such tee suffices. For replacement, the firm must stock six tees—one with all metric threads, one with all English threads, one with metric threads on the line and English on the tee, one with English threads for the line but metric for the tee, and finally two tees with metric threads on one end of the line and English on the other but providing for either thread on the tee. With installations already in place, cutting new threads is not always possible, and if it can be done, means added expense.

It would be necessary to rewrite all technical literature, including standard reference handbooks, to say nothing of the necessity of adding the new notation to all working drawings. It is not at all uncommon for a firm to use over 100,000 working drawings, on which the dimensions are given in the English system. All these would have to have the new notation added, yet should carry the old as well, in order to provide repair and replacement parts for parts and machines now in use.

If we change from miles to kilometers, among other items would be the necessity of replacing every sign relating to speed limits on the highway by a sign involving kilometers. Since it is not feasible to replace a sign reading "Speed limit 40 miles per hour" by one reading "Speed limit 64.374 kilometers per hour" it is likely that the limit would be changed to 65 kilometers per hour. This would involve the expense of new legislation and the printing of new laws. Not only speed limit signs, but signs giving distances would need replacement. Some twenty years ago an estimate of the cost of changing some 250,000 or more railway mile posts then in service was considered to be more than a million dollars; certainly the present cost would not

be less. With the change in highway regulations and mileage signs would come the need for replacing the dial on every speedometer on every automobile, or else educating drivers to convert from miles to kilometers. Would this ability be a part of the examination for a driver's license?

With the change in measurement, all existing tape measures, yard sticks, and engineers tapes would be scrapped, for the cost of rescaling would be as much as that of a new unit. All cook books would need to be rewritten; all present kitchen measuring devices would be obsolete. All peck and bushel measures, all computing scales, would become illegal; every milk bottle now in existence would be illegal unless marked in metric units. Every gas and water meter would have to be recalibrated; as would measuring machines such as are used for yard goods in department stores. The list is by no means exhaustive, but is indicative of the magnitude of the change proposed.

An item of expense often overlooked, but by no means minor, is that with a compulsory system, there would be added governmental expense for inspection and enforcement. Whether this be done on the local, state, or national basis, the expense is still there.

If your 1949 car needs a new bolt in 195?, after adoption of the metric system, a new metric bolt, that looks like the old one, will not fit. In other words, every builder of an automobile, refrigerator, typewriter, sewing machine, or other machine must manufacture and stock two kinds of bolts and other parts including screw threads until the last of the old machines wears out.

VI. *Miscellaneous considerations.* All legal descriptions and conveyances of property would involve the English system on old surveys; the conversion factors; and the metric system used for new surveys.

A change to metric units would mean that it would not be feasible to compare much of the statistical data compiled by the Bureau of the Census and other agencies. Granted that conversion factors are possible, their use involves much computation, yet without such conversion, comparison of data before and after the adoption of the new system is almost impossible.

The plan often suggested, of applying metric equivalents and nomenclature to our present standards, making no changes in our present physical dimensions, is not feasible, since the units are not commensurable. Moreover, even approximate equivalence results in very awkward expressions: a 50 foot length of $\frac{3}{4}$ inch hose becomes 15.24 metres by 19 mm.; a shirt with 15 inch collar and 32 inch sleeve becomes size 381×813; a 2′6″ by 6′8″ door becomes 762×2032 mm.; an ordinary brick is $51 \times 101 \times 203$ mm.

It is argued that the metric system saves time in making computations in industry. This ignores the fact that the goal of industry is making *things*, not computations. Any concern will cheerfully spend extra time in computation if there is promise of saving time in the factory. With the modern system of gages used in the factory, the worker cares not whether the gage is in the English, metric, or Hottentot system. It makes no difference, neither has any advantage as a time saving device.

References

Since an excellent presentation of the other side of the question is readily available in the Twentieth Yearbook of the National Council of Teachers of Mathematics, already referred to, this brief bibliography is restricted to references which emphasize arguments *against* adoption of the metric system. A rather extensive bibliography of references prior to 1926, covering both sides of the question, will be found in Volume III, Number 8, of *The Reference Shelf*, which will be found in many libraries. In the listing which follows, references more than thirty years old, that is, prior to approximately 1920, are not included.

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SHAPLEY PICKS 10 TOP ASTRONOMY EVENTS OF 1949

The ten top astronomical events of 1949 were picked by Dr. Harlow Shapley, director of the Harvard College Observatory:

1. Operations in large optical glass for telescopes, including Lick Observatory's 120-inch disk obtained from California Institute of Technology, British acquirement of a 98-inch disk from the McGregor Foundation in this country, ordering of 74-inch disks for telescopes on Australia's Mt. Stromlo, Egypt's Helwan Observatory, and San Michele Observatory.
2. Beginning of operation of the 200-inch and 48-inch Schmidt on Mt. Palomar and the Radcliffe 74-inch at Pretoria, South Africa.
3. Radar observations on the moon at eclipse by Winfield W. Salisbury at Cedar Rapids, Iowa, that show it covered by non-conducting layer of dust.
4. Discovery of an asteroid of 400-day period that goes nearer sun than the planet Mercury.
5. New theory that comet heads are composed of ices of gases and meteoric particles that melt to form the head when near the sun.
6. Various new theories of cosmic ray origin that involve magnetic fields.
7. Discovery of the second satellite of Neptune by Dr. C. P. Kuiper of Yerkes and Davis Observatories.
8. Discovery by Dr. W. J. Luyten of University of Minnesota of a nearby pair of extreme dwarf red stars, one of which has mysterious flares and flashes.
9. Work on the colors of stars by Dr. Olin J. Eggen of Lick Observatory.
10. Discovery by Dr. G. Haro of Mexico that objects formerly thought globular clusters are Pleiades-like groups of stars and nebulosity.

LARGEST CIRCULAR PHOTOGRAPHIC PLATES TO BE USED WITH NEW TELESCOPE

Seventy dozen of the largest circular photographic plates ever used by astronomers are being rushed to completion by Eastman Kodak research scientists, the company announced. The infra-red and -blue sensitive plates will be used on the "Hub of the Universe" expedition of Harvard University astronomers.

A team of Harvard astronomers will use the plates with a new type of telescope and the world's largest objective prism to study more than one million stars and other interstellar bodies in the Milky Way. The astronomers will use the new telescope to photograph the center portion of the Milky Way, more than 30,000 light years from the earth. Present telescopes have been limited to detailed explorations of stars less than 10,000 light years distant.

HIGH SCHOOL SCIENCE AND MATHEMATICS—FOR WHOM AND FOR WHAT?

CHARLES W. SANFORD
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In all likelihood every person in this room has considered, on many occasions, the extent to which high school science and mathematics should be directed toward preparation for college. Certainly, many, if not all, of you would agree that in most schools—particularly in the eleventh and twelfth grades—this consideration has been an academic one.

The consideration has been an academic one in Illinois, because we know that in 1947–48 only 7% of the high school population enrolled in chemistry; 6%, in physics; and 3.4%, in eleventh and twelfth grade courses in mathematics;[1] while 70% of the youth entering college in September of 1948 had completed courses in physics; 62%, courses in chemistry, 63%, 2½ units in mathematics; 51%, 3 units in mathematics; 12%, 3½ units in mathematics; and 6%, 4 units in mathematics.[2] In considering these figures, we should keep in mind the fact that less than 60% of the youth of eleventh and twelfth grade ages were in school.

We are now gathering data which will indicate the number of students in grades eleven and twelve who enrolled in chemistry and in the other subjects mentioned.

These data lead us very abruptly into the topic, "High School Science and Mathematics—For Whom and For What?" While present practice indicates that the answer to one phase of "For Whom?" at the eleventh and twelfth grade levels in Illinois is "for college-bound students," this may not be the answer we like; but before we look at what we may or may not like, it may be apropos to examine the picture in grades nine and ten. Here we found that 19% of all high school students were taking general science; 19%, biology, 20%, ninth grade algebra; 11%, some other ninth grade course in mathematics; and 13%, plane geometry.[3] Of the students who entered college, 80% had completed general science; 63%, biology; and 100% had completed two or more years of work in mathematics.[4]

[1] Data obtained from a random sample of the reports submitted to the Office of the High School Visitor University of Illinois and to the Office of the Superintendent of Public Instruction by Illinois high schools for the school year, 1947–48.

[2] Data obtained from a random sample of the high school records of students who entered the University of Illinois in September, 1948. The entrance requirements of the University of Illinois may have influenced somewhat these percentages; this influence was probably negligible in view of the similarity in entrance requirements of the University of Illinois and those of many of the other higher institutions in Illinois.

[3] Data from source indicated in footnote 1.

[4] Data from source indicated in footnote 2.

What is the explanation for this picture? We might turn first to legal enactments. They stipulate in Illinois the study of physiology and of health by all public school pupils in grade nine. These provisions may be met in several ways; an analysis of the program of studies of Illinois high schools indicates clearly that they are ordinarily met through a required one-year course in general science. The study of mathematics is not required by statute.

Next, we might seek an explanation for the picture in the kinds of courses offered by high schools. An analysis of a sample of the programs of studies in 240 of the 736 public high schools in Illinois in 1946–47 revealed that the schools made available to students a reasonably diversified list of courses. Ninth and tenth grade science and mathematics were so customarily available that no percentages need to be cited. However, less than 50% of the schools with fewer than 250 pupils offered chemistry, and approximately 15% of these schools did not include physics in the program of studies. These data are interesting in view of the fact that 522 of the 736 schools in Illinois were in this enrollment category.

Practical mathematics was available in about 50% of the schools with less than 250 students and in about 75% of the schools with more than 250 students; advanced algebra, in approximately 50% of the schools with less than 100 students and in more than 90% of the others; solid geometry, in about 30% of the schools with fewer than 100 pupils, in 63% of the schools with 100 to 249 pupils, in 83% with 250 to 499 pupils, and in more than 96% of the schools with 500 pupils or more; trigonometry was available in about the same pattern as solid geometry, except that it was available in fewer schools with less than 50 pupils; college algebra was not offered in any school that had less than 500 pupils, but it was offered by 3% of the schools with 500 to 999 pupils, by 31% with 1000 to 1999 pupils, and by 43% with 2000 or more pupils.[5]

The explanation for the discrepancy between the amount of science and mathematics taken by college and non-college bound students is found, in large measure, in college entrance requirements.

These data merely point to certain phases of present practice, to parts of the "What is?" picture in science and mathematics in one state, not to the "What should be?" However, all of us realize that whenever changes are made, we have to start where we are. This means that when we launch a program of curriculum improvement in science and mathematics, it is well to know as much as possible about present practices in these areas.

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[5] Godshalk, Frederick I. and Proctor, Dixie C. "Analysis of the Program of Studies of Illinois Public High Schools for the School Year 1946–47." Office of the High School Visitor and University Council on Teacher Education, University of Illinois, April 23, 1947, pp. 19–20. (Mimeo.)

Time does not permit a detailed analysis of present practice. However, you might be interested in obtaining several publications reporting the findings of Illinois studies which push much further this analysis. In brief, these studies[6] were concerned with the following questions:

1. Is the holding power of our school satisfactory in terms of accepted democratic goals? The range in drop-outs, in 76 representative schools, was from less than one to as many as eight for every ten who were graduated. On the average, for every ten who received diplomas, approximately 3 had dropped out. Our composite findings revealed that boys dropped out in larger proportions than girls; that almost all of the drop-outs were receiving, when they withdrew, very low marks; that children from lower-income families dropped out in much larger numbers than those from middle and upper-income groups; and that there was no appreciable difference in the holding power of small and large high schools.
2. Are the costs connected with certain phases of the school's program depriving some youth of the very experiences they need? I cannot resist the temptation to state that in 79 representative schools included in this study, the median cost to pupils who attended schools in which textbooks were purchased by the pupils was $3.75 for twelfth grade science, and the highest cost reported was $10.25. The median costs of belonging to the biology and science clubs were $2.50 and $1.25, respectively; the highs were $7.50 and $39.90 respectively. Similar data were obtained for all subjects and extra-class activities offered in these schools.
3. Are pupils in our high schools participating in extracurricular activities according to their needs, interests, and abilities? Do certain factors operate which make participation selective in one or more respects?
4. Are the available guidance services both adequate and effective? Our findings, from one part of this study, indicated that the major concerns of girls were in the area of "Personal-Psychological Relations": "Losing my temper," "Nervousness," "Worrying," "Can't make up my mind about things," "Can't see the value of daily things I do," etc. The boys were most concerned with problems of "Adjustment to School Work": "Taking

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[6] Sanford, Charles W., "Challenging Developments in the Illinois Secondary School Curriculum Program," *The Bulletin of the National Association of Secondary-School Principals*, Volume 33, Number 162, April, 1949, pp. 57–65.

Hand, Harold C., *Principal Findings of the 1947–1948 Basic Studies of the Illinois Secondary School Curriculum Program.* Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 2, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949. 77 p.

wrong subjects," "Not getting studies done on time," "Worrying about grades," "Slow in reading," "Trouble in using the library," "Can't see that school is doing me any good," etc. Both boys and girls were bothered about problems concerned with "Curriculum and Teaching Procedures": "Dull classes," "Made to take subjects I don't like," "Poor place to study at home," "Textbooks hard to understand," "Teachers too theoretical," "Wanting subjects I'm not allowed to take," etc., as well as problems concerned with "The Future: Vocational and Educational": "Needing to decide on an occupation," "Not knowing what I really want," "Concerned over military service," "Deciding whether or not to go to college," etc. Typically, twelfth grade pupils exhibited about 75 per cent knowledge of vocational trends and of the nature of the work involved in a sampling of representative occupations and a 67 per cent knowledge regarding unfounded beliefs which lead to unfortunate vocational and educational choices.

Obviously, these questions break down into many parts. I am leaving on the platform mimeographed sheets which list the publications[7] in which these and other findings are reported. They may be obtained, without cost, from Mr. Vernon L. Nickell, State Superintendent of Public Instruction, Springfield, Illinois.

All of this brings us to a consideration of the two-part question, "Who should enroll in high school science and mathematics, and for what?" In attempting to answer these questions, we are proceeding, in Illinois, as follows:

1. We are proceeding in terms of the following assumptions and beliefs. By "we" is meant the Steering Committee of the Illinois Secondary School Curriculum Program, a program

[7] Houston, Victor M., Sanford, Charles W., and Trump, J. Lloyd, *Guide to the Study of the Curriculum in the Secondary Schools of Illinois*. Circular Series A, No. 51, Illinois School Curriculum Program Bulletin No. 1, Office of the State Superintendent of Public Instruction, Springfield, Illinois. August, 1948. 42 p.

Hand, Harold C., *Principal Findings of the 1947–1948 Basic Studies of the Illinois Secondary School Curriculum Program*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 2, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949. 77 p.

Allen, Charles M., *How to Conduct the Holding Power Study*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 3, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949. 128 p.

Hand, Harold C., *How to Conduct the Hidden Tuition Costs Study*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 4, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949. 51 p.

Hand, Harold C., *How to Conduct the Participation in Extra-Class Activities Study*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 5, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949. 66 p.

Lovelass, Harry D., *How to Conduct the Study of the Guidance Services of the School*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 6, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949.

Benne, Kenneth D. and Muntyan, Bozidar, *Human Relations in Curriculum Change*, Selected Readings with Special Emphasis on Group Development. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 7, Office of the State Superintendent of Public Instruction, Springfield, Illinois. June, 1949.

sponsored by the State Superintendent of Public Instruction, Mr. Nickell, in cooperation with colleges and universities and 39 lay and professional organizations. Among the cooperating organizations are the Illinois Association of Chemistry Teachers, the Illinois Association of Teachers of Biology, and the Illinois Council of Mathematics Teachers.

(a) In the two-year period in which the Illinois Secondary School Curriculum Program (hereinafter referred to as ISSCP) has been in operation, we have been convinced that relatively little will be accomplished by individual subject groups working in isolation from other groups, though such efforts will ordinarily lead to improvements. Curriculum work which is effective calls for a high order of cooperation at the local school level. This cooperation means participation by many members of the faculty; ideally, by all members of the faculty. It also means participation by school board members, by parents, by laymen who are not parents, and by pupils. As a consequence of this belief, Illinois schools which have projects sponsored by the ISSCP are encouraged to establish at the local level organizations which include all of the persons and groups who are, or who should be, interested in the high school curriculum.

An excellent example of an all-school study of a particular problem is found in the Oak Park Township High School in Oak Park, Illinois. Through the excellent leadership of Miss Charlotte L. Grant, Head of the Biological Science Department and of Mr. Eugene Youngert, Superintendent, a school-wide program in health is being developed. I quote a portion of the report which Miss Grant presented at the last meeting of the Illinois Academy of Science. " . . . As an experimental procedure in one four-year high school of nearly three thousand students, a replacement of general science by a health science course is underway. This course is required of all ninth grade students, for five or seven periods a week. There are usually twelve or thirteen classes each semester, taught by instructors in the department of biological sciences. The experiment is approaching the end of its third year.

"The course, although constantly undergoing revision as suggestions for betterment are received, is at present organized into four units. These are tentatively titled *The Human Body—a Machine, The Young Person at Home, The*

Young Person at School and in the Community, and the *Young Person at Leisure.*"

. . . Health education is not forgotten at the end of the freshman year, but continues as an important part of the curriculum through four years of physical education and after-school recreational activities, through biology which is an elective science after the freshman year, and through phases of home economics, social science, and English. Into biology has been placed the study of heredity, reproduction, growth from birth to maturity, boy-girl relationships, behavior mechanisms, disease control, and other human interest material."[8]

A Health Council is very active, teachers and pupils collaborate in determining health needs, physical examinations are administered and followed up with the cooperation of parents, student diets receive particular attention, building changes are continuously improving the health environment, a high order of coordination obtains between the school and community agencies, and so on.

(b) One of the major points upon which the State Steering Committee agreed is that we should assist every participating school and community to get the facts about itself that are basic to curriculum revision. The Committee correctly insisted that we have, for too long, made changes on the basis of hunches, or as a result of supersalesmanship by someone. In addition to the studies mentioned earlier on holding power, hidden tuition costs, guidance, and extra-class activities, you will be interested in a study which is presently being completed by one of my colleagues at the University of Illinois and a member of this Association, Professor Kenneth B. Henderson. We call it a Follow-Up Study. Through it we are trying to find answers to two questions, namely, "How may we build a strengthened teacher-pupil-school-patron consensus regarding the 'need meeting' function of the secondary school?" and "How may we appraise the extent to which the local school is, or is not, now meeting the real-life needs of its secondary school youth?" The five instruments, each of the check type, which were used in this Follow-Up Study in 97 schools, focus attention upon 55 real-life problems of youth. Examples of several problems on this list which seem to be closely related to science and mathematics are " . . . the

[8] Grant, Charlotte L., "Health Instruction in the Biological Sciences." (From an address delivered to the Illinois State Academy of Science, Galesburg, Illinois. May 7, 1949.)

problem of acquiring the ability to care for one's health and of developing good health habits. . . . The problem of learning how to drive and care for an automobile. . . . The problem of ridding one's self of religious and racial prejudices . . . " as well as numerous problems in the general areas of "Managing Personal Finances Wisely" and "Making Effective Use of Educational Opportunities." Teachers, pupils, parents, and laymen who are not parents were asked anonymously to indicate whether or not the high school should help pupils with each problem cited. If the response was in the affirmative, they were asked to state how important it is for the school to provide such help. Teachers were also asked to evaluate the extent to which they believed graduates typically received help on each problem. Graduates were requested to indicate which of the problems they were experiencing, how much of the help they needed for each problem they obtained in high school, and how effectively they believed they were meeting each problem. Another study is now being launched which is designed to push further these local analyses of the purposes of each instructional area and of the practices followed in each area to the end of providing for each participating school a picture of the extent to which it is, or is not, now meeting the needs of youth.

(c) We have assumed that the curriculum consists of all of the experiences which pupils have under the control of the school; thus it includes all organized activities of the secondary school.

(d) Effective curriculum revision is a *grass roots* job. Local communities under the leadership of the school staff must study the demands of society and the basic needs of individuals in order to develop programs of secondary education suited to students in their communities and to try them out in action.

(e) Curriculum revision will, we believe, be effective to the degree that it is accompanied by continuous evaluation of the extent to which clearly defined objectives are being reached.

So much for some of the assumptions and beliefs which give direction, in the Illinois program, to answering the question, "Who should enroll in high school science and mathematics, and for what?" Let us push the analysis beyond assumptions and become more specific.

2. In the *Guide to the Study of the Curriculum in the Secondary Schools of Illinois* we have indicated who should take high

school science and mathematics and, in general terms, what should be included in these areas, in the following statements:

"The purpose of the school is to provide learning experiences so that the needs of youth and the requirements of society may be met effectively. The means of accomplishing that end, that is, the selection of what learning experiences may best meet youth and societal needs, constitutes a basic task of curriculum makers.

"Curriculum construction might, therefore, be viewed in part as a sifting process wherein a selection from all possible learning experiences is made. What youth need and what society seems to require may constitute the sieve. All of the accumulated social and cultural heritage is available to those who teach. The teacher must select those experiences which will be most profitable to youth and adults.

"Since all youth have certain needs in common and the social setting presents certain requirements common to all citizens in a democracy, a portion of the school day may be devoted to these 'common learnings' of all youth. This would not change the policy of providing a wide offering of other subjects on an elective basis."[9]

Several of these common needs, if met, call for learning experiences in science and/or mathematics as follows:

"1. Mastering the tools of communication
  "a. Becoming effective in the use of words and symbols
  "b. Developing facility in the use of the mathematics of everyday living
"2. Developing a strong body and a sound attitude toward it and toward good health practices
  "a. Understanding and acceptance of physique
    "(1) Differentiating on the basis that one is becoming a man or a woman
    "(2) Appreciating rapid growth and physical change
    "(3) Accepting abnormal physical characteristics and adaptations necessary for successful life with them
  "b. Developing sound mental hygiene . . .
"5. Acquiring knowledge of, practice in, and zeal for democratic processes
  "a. Learning to be intelligently critical of the social heritage

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[9] Houston, Victor M., Sanford, Charles W., and Trump, J. Lloyd, *Guide to the Study of the Curriculum in the Secondary Schools of Illinois*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 1, Office of the State Superintendent of Public Instruction, Springfield, Illinois. August, 1948, p. 10.

"(1) Possessing an understanding of and belief in our culture

"(2) Being able to gather the facts regarding society and evaluate them

"(3) Developing ability to be independent in arriving at judgments; must not merely imitate a teacher or leader

"(4) Being able to propose a plan and see the consequences if the plan is adopted

"d. Developing an understanding of the necessity for international peace together with some knowledge of how to further it

"e. Understanding relationships between the sciences and human destiny . . .

"7. Becoming an effective consumer

"a. Saving money and time sufficient to provide security

"b. Buying wisely

"c. Using materials effectively

"d. Making effective use of the services of institutions and governmental agencies . . .

"9. Developing meaning for life

"a. Sensing moral and spiritual values

"b. Thinking objectively and using the scientific attitude . . ."[10]

Do we emphasize in practice—or just talk in meetings like this one—teaching pupils to be critical, to weigh, to judge, to analyze, and so on? Most of the physics and chemistry teachers in this room have doubtless read the New York *Syllabuses in Physics and Chemistry*. It states, on this point,

"Most important of all, the pupil should be started along the road to a scientific habit of mind, with fearless inspection of data and conclusions, and with the development of intellectual honesty and love of truth that will carry over into his future judgments in all subjects of life."[11]

Wouldn't it be grand if science and mathematics teachers in each high school would spearhead a school-wide effort to teach the more extensive use of the problem method?

These statements answer quite clearly the question, "Who should enroll in high school science and mathematics and for what?" The answer of the ISSCP is, in part, "All youth should have learning experiences in high school science and mathe-

[10] *Ibid.*, pp. 15–17.

[11] The University of the State of New York, The State Education Department, *Syllabuses in Physics and Chemistry* (Revision of September 1938). The University of the State of New York Press, Albany. 1945. p. 5.

matics which will meet common youth and societal needs." If substantiation for this answer is needed, we may obtain it in large quantities, as you know, from such publications as *Education for All American Youth*, the Report of the Harvard Committee on *General Education in a Free Society*, and the Final Report of the Commission on Post-War Plans of the National Council of Teachers of Mathematics on *Guidance Pamphlet in Mathematics for High School Students*. These, and many others, are most helpful.

You will note that the answer did not specify the manner in which the learning experiences should be organized. Since no one has as yet proved the superiority of the common learnings approach, the broad fields approach, or the individual subject approach, we believe that each school should be given every opportunity to experiment with the one it prefers. While doing so, we hope that the experimentation will involve a methodology which will lead to more conclusive answers than those now available.

Another important phase of the question, "Who should enroll in high school science and mathematics?" is concerned with meeting certain special interests of pupils. On this point our *Guide* states, "There is no real issue between education to serve the demands of our democratic society and education to further the best interests of the individual. One of the demands of a democratic society is that every individual be brought to the highest level of attainment possible for him. . . . There is no real issue between the basic tenet of 'general' and 'vocational' education; an education which actually meets the needs of youth will maintain, in the case of each individual pupil, a proper balance between these two kinds of needed preparation."

Most of us will agree that common needs have been neglected more than specialized needs. At the same time, we will agree that we have only begun to explore the steps involved in challenging as completely as possible the specialized interests of boys and girls in our high schools.

The determination of these special interests to be pursued by a given pupil presents a guidance problem of considerable magnitude. The fact that some schools are meeting this problem quite successfully should encourage other schools to tackle it more vigorously.

3. To implement these steps, the ISSCP is cooperating with more than 200 schools in various types of curriculum projects; in 38 selected school systems, this cooperation is concerned with the

development of 74 experimental projects. These projects are concerned with the improvement of existing courses in mathematics, science, social studies, etc.; with enrichment in broad fields; with the development of common learnings courses; and with projects which cut across subject lines.

As many of you know, a team of consultants from the State Department, colleges, universities, and other schools cooperates with persons affiliated with a given local school, in attempting to develop a superior program. If and when superior programs have been developed, the local teachers and administrators will help other schools on similar projects; moreover, as the local projects are being developed, teachers and administrators from other schools are encouraged to study what is going on.

A number of the emphases and redirections in these projects which may be of particular interest to teachers of science and mathematics follow:

1. Successful revision programs in a local school must be directed toward meeting more adequately the needs of all youth, not the needs of one or two or three groups of youth. A good example of this redirection is found in the mathematics program in the junior and senior high schools in Moline. The intent is to provide all pupils with an enriched offering by means of a "broad front approach." This approach involves teaching arithmetic, algebra, geometry, and trigonometry in grades seven to ten. To quote the "Progress Report of the Moline Mathematics Curriculum Project" which was prepared by a committee with Mr. Owen S. Day as Chairman, "The broad front approach means that in each year we will teach as much of arithmetic, algebra, numerical trigonometry, and formal geometry, as the pupil is capable of acquiring. Each year contact will be made with these areas, general emphasis being placed on particular areas in each year. For instance, the major part of our offerings in the seventh and eighth grades will be arithmetic with introductions to algebra, informal geometry, and numerical trigonometry . . . ."
2. Emphasis is being placed upon making the school's offering more functional; more specifically, upon real-life problems.
3. Whenever such problems are stressed, we find in the schools more and more emphasis on good work habits, how to work with others, understanding ourselves, developing a zeal for the democratic way of life, conservation, health, problems of community, state, national, and international concern, and a choice of appropriate school subjects.
4. Whenever such problems are stressed, we also find more and more attention given to sharpening the guidance program to the

end of identifying as early as possible the interests and abilities of students so that there may be provided learning experiences which will be of greatest value. We may agree, with better guidance, that college-bound pupils with certain abilities should be challenged to much higher levels of accomplishment in science and mathematics than has been the case in our traditional programs; we may also agree that some of the pupils who are now taking ninth grade algebra could more profitably spend their time on other types of learning activities.

One of our projects has been concerned with the provision of improved learning opportunities for intellectually gifted pupils in the Woodruff High School, Peoria. In June, 1949, at the end of the first year of this experiment, Mr. Dane Harris, Adviser, and Mr. Fred Barnes, who was then Director of Curriculum in Peoria, reported, "The students expressed a feeling of need for much more direct faculty guidance and direction. . . . They projected most of the blame for the difficulties encountered in the course on their previous eleven years of schooling. 'How can you expect us to work this way when we have had eleven years of assignments and being told how to do everything' . . . ."

Several tentative generalizations cited were:

"1. At least 50% of the superior students at the senior high school level need direct faculty guidance and assistance, both in an academic and emotional sense. In terms of the whole group this guidance varies from almost adult relationships between teacher and student to semi-paternalism. The sole fact of intellectual superiority by no means implies ability to conduct fruitful self-directed activity.

"2. As implied above, high I.Q. and even high academic achievement play only a partial role in the behavior of the gifted. The psychology of the home and the best past pedagogy of the school are persuasive factors in total behavior."[12]

In conclusion, we should again look at the topic "High School Science and Mathematics—For Whom and For What?" The facts indicate that most of the pupils in the ninth and tenth grades enroll in courses in science and mathematics; they also indicate that relatively few pupils in the eleventh and twelfth grades take courses in these areas. If we hope to meet youth and societal needs, we must provide learning experiences in science and mathematics in the eleventh and twelfth years.

My enthusiasm for far more experimentation with common learn-

[12] Harris, Dane and Barnes, Fred, "A High School Experiment with Intellectually Gifted Pupils." A report of the senior problems course offered at Woodruff High School, Peoria, Illinois in cooperation with the Illinois Secondary School Curriculum Program, 1948–49. Pp. 21–22.

ings courses stems in no small part from the opportunities which they provide for including, in the eleventh and twelfth grades, important learning experiences involving science, mathematics, and other areas ordinarily neglected in these grades. In this setting content from these neglected areas would be studied in relation to problems to be solved.

Since nearly all students in the ninth and tenth grades take science and mathematics, we have a major problem in scrutinizing very carefully and in terms of a very realistic consideration of youth and societal needs, the offerings which we make available. In any given school situation if we are going to accomplish much with this and the other problems mentioned we need to (1) dig out the facts that are pertinent to a revision program, and (2) tackle the program on a much wider front. This means that we should seek and obtain the cooperation of other teachers in the school, of pupils, and of laymen.

A NEW SCIENCE SERVICE FOR PROFESSIONALS AND LAYMEN

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Last September approximately 3,300,000 pupils reported to classrooms taught by teachers with sub-standard training. A year before, 7,633 classrooms remained closed, because not even emergency credential teachers were available to welcome 61,750 American children. Doors of education were slammed in the face of these children, and they were sent away to work in the fields, to rove the streets, and to break the laws of our country.

C. C. TRILLINGHAM
EMERY STOOPS
CTA Journal

SELECTED REFERENCES FOR HIGH SCHOOL PHYSICS*

SYLVAN MIKELSON
University High School, Columbus, Ohio

I should like to question for a moment the purposes which we hold for the education of our young people. Just exactly what is the purpose of our high school physics course? Let me push the question a little further. What is your role in helping to educate the students in your school? Is the material that you teach really valuable to your students in meeting their needs and furthering their interests? How does your teaching actually affect the behavior of your students?

Alfred N. Whitehead has said this of education:

> There is only one subject for education and that is life in all its manifestations. Instead of this single unity, we offer children—Algebra, from which nothing follows; Geometry, from which nothing follows; Science, from which nothing follows; History, from which nothing follows; a couple of Languages, never mastered; and lastly, most dreary of all, Literature, represented by plays of Shakespeare, with philological notes and short analyses of plot and character to be in substance committed to memory. Can such a list be said to represent Life, as it is known in the midst of the living of it? The best that can be said of it is that it is a rapid table of contents which a Deity might run over in his mind while he was thinking of creating a world, and has not yet determined how to put it together . . . .

The purposes of education have received the attention of educators for many years. Suffice it to say that any objective must lie within the all inclusive purpose which is the fullest possible development of the individual within the framework of our present industrialized democratic society. Living in our fast moving mechanized culture is, in a sense, a "quest for certainty." Critical thinking is particularly necessary in a democracy where each individual is responsible to manage his own life and share in guiding the policies of our country.

Our area of science has much to contribute to the improvement of reflective thinking in personal and social living. We should face our responsibility. This calls for an emphasis upon the problem approach which must be genuine to the student, rather than merely important to us teachers. "Science instruction too often confines the application of the scientific method to the more abstract problems of the laboratory, with definite loss as regards living processes. For example, the first phase of the process, 'sensing a need,' is for the most part short circuited for the students, and thus little of value is learned for application of life problems."

I should like to borrow the illustration used by Dr. Emmett Brown in his article on "The Plight of High School Physics."

* Read at the Physics Section of the Central Association of Science and Mathematics Teachers, November 25, 1949.

Jim Smith comes into the physics laboratory in A——— High School. He was told during the previous day's class period to read over Experiment 14, "The Composition of Forces" in Blank, Blank and Blanks' Laboratory Manual in Glorified Physics. Now this experiment is worthy of the veneration that is accorded the aged in all well-regulated societies. Under this same title and in only slightly different form it appeared in the Harvard Descriptive List of Experiments in 1886, and in several of the other early standardizing reports. The same is true of many of the other experiments in this manual. But Jim is unaccountably lacking in his reverence for lusty senility. He has not read the experiment. Educators are aware that the laboratory trains in the scientific method of solving problems—that is, the laboratory is the place to "put questions to nature." But Jim, not being an educator, doesn't know this, and so he proceeds to plod stodgily through the experiment, taking his directions from the manual line for line, in cook book style. He has no problem to solve—except the personal one of getting through the experiment, with a minimum of labor and thought. He does have a little bad luck. He draws the angles of his force parallelogram carelessly and the resultant does not equal the equilibrant. Jim doesn't notice the error. Why should he? But his teacher, Dr. Pangloss, does. "You will have to do the experiment over." But the laboratory period is nearly over. After school hours will be required for the second performance. Here at last is a real problem—how to avoid extra hours! Jim is by no means stupid. A little juggling of figures, a little consultation with his classmates, and Jim is able to submit a drawing of force values which elicit Dr. Pangloss's approval. A written report is required. This is turned in the next day. In it Jim concludes that he has "proved" that the resultant always equals the equilibrant.

We should not conclude that this experiment has been without value to Jim. True it has rather stifled whatever interest in experimentation he has retained from previous laboratory periods. He has received no insight into the scientific method. But he has had something to do during the period. And that last little brush with the teacher was interesting. For, not knowing that the laboratory teaches mental rectitude, Jim has been smart enough to "doctor" his results so that the values for the resultant and equilibrant are neither so close as to excite suspicion nor so much in variance as to evoke another demand for repetition.

We need not raise the question of whether Jim's laboratory experience typifies that of other students in our science laboratories.

The point I would like to make is that you as teachers cannot dictate real problems to your students. To be a real problem to the pupil, it must come from within the thinking of the student himself. I am suggesting to you this afternoon that here, in the classroom reference library, is one place children can get problems that are meaningful to them. And at the same time they are building a large reservoir of knowledge which lies in their field of interest.

This list is an addenda to that selected by Dr. G. P. Cahoon and presented here in the fall of 1947. His list can be found in SCHOOL SCIENCE AND MATHEMATICS of January, 1948. The list does not purport to include "the" best books for high school physics. There are scores of other excellent books, some of which many will feel should have been included. Obviously "best" for one teacher and for a particular group of students is not necessarily best for another or another student group in a different situation.

I have included only those books published since 1947. The organization follows that used by Dr. Cahoon.

Atoms

Davis, Harry M., "Energy Unlimited," Murray Hill Book Co., 1947, pp. 273.

Biography-History

Shippen, Katherine H., "The Bright Design," The Viking Press Co., 1949, pp. 202.

Electricity

Skilling, H. H., "Exploring Electricity," Ronald Press Co., 1948, pp. 272.

Suffern, M. G., "Basic Electrical Principles," McGraw-Hill Book Co., 1949, pp. 430.

General

Crouse, William H., "Understanding Science," McGraw-Hill Book Co., 1948, pp. 182.

Finch, Trewartha, and Shearer, "The Earth and Its Resources," McGraw-Hill Book Co., 1948, pp. 572.

Morgan, Alfred P., "Boy's Book of Science and Construction," Lothrop, Lee, and Shephard Co., 1948, pp. 461.

Newkirk, Hewitt, and Zutter, "Adventures with Plastics," D. C. Heath and Co., 1947, pp. 270.

Swezy, Kenneth M., "After Dinner Science," McGraw-Hill Book Co., 1948, pp. 178.

Zim, Herbert S., and Cooper, Elizabeth K., "Minerals," Harcourt Brace and Co., 1943, pp. 355.

Radio-Electronics

Grob, Bernhard, "Basic Television Principles and Servicing," McGraw-Hil Book Co., 1949, pp. 588.

Hickley, H. T., "Principles and Practice of Radio Servicing," McGraw-Hill Book Co., 1948, pp. 391.

Hornung, J. L., "Radar Primer," McGraw-Hill Book Co., 1948, pp. 210.

Sound-Music

Geralton, James, "The Story of Sound," Harcourt Brace and Co., 1948, pp. 72.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well cone in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.
2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.
3. In general when several solutions are correct, the one submitted in the best form will be used.

Late Solutions

2170. *C. W. Triggs, Los Angeles City College*

2171. *W. R. Talbot, Jefferson City, Mo.*

2170, 1. *Bernard Katz, Brooklyn.*

2173. *Proposed by C. W. Trigg, Los Angeles City College.*

Evaluate

$$\sum_{n=0}^{\infty} \frac{(2n+1)!}{2^{3n}(n!)^2}.$$

Solution by Max Beberman, Shanks Village, N. Y.

It is well-known that for $|x|<1$ and for m not a positive integer

$$(1+x)^m = 1+mx+\frac{m(m-1)}{2!}x^2+\cdots. \tag{1}$$

Hence for $x=-\frac{1}{2}$ and $m=-\frac{3}{2}$ we have

$$2\sqrt{2} = 1+\frac{3}{2}\cdot\frac{1}{2}+\frac{3\cdot 5}{2\cdot 4}\cdot\frac{1}{2^2}+\cdots = \sum_{n=0}^{\infty}\frac{1\cdot 3\cdot 5\cdot 7\cdots(2n+1)}{2\cdot 4\cdot 6\cdots 2n}\cdot\frac{1}{2^n}. \tag{2}$$

But

$$\frac{1\cdot 3\cdot 5\cdot 7\cdots(2n+1)}{2\cdot 4\cdot 6\cdots 2n}\cdot\frac{2\cdot 4\cdot 6\cdots 2n}{2\cdot 4\cdot 6\cdots 2n} \equiv \frac{(2n+1)!}{2^{2n}(n!)^2}.$$

Hence

$$\sum_{n=0}^{\infty}\frac{(2n+1)!}{2^{3n}(n!)^2} = 2\sqrt{2}. \tag{3}$$

Other solutions were also offered by the following: Hugo Brandt, Chicago, Ill.; and the proposer.

2174. *Proposed by W. R. Talbot, Jefferson City, Mo.*

Solve for x:

$$4RSx^3-2S\left(\frac{1}{\sin A}+\frac{1}{\sin B}+\frac{1}{\sin C}\right)x^2+2px-1=0$$

where

$$\frac{S}{p} = 4R\sin\frac{A}{2}\sin\frac{B}{2}\sin\frac{C}{2}.$$

Solution by the proposer

The given condition indicates that the coefficients of x are related to the parts of a triangle ABC with area S and semi-perimeter p, for we recognize it as two expressions for the inradius. For such a triangle, we know $2p=a+b+c$, $S=abc/4R$ and $2S=ab\sin C=ac\sin B=bc\sin A$. The equation may be written as

$$abcx^3-(ab+ac+bc)x^2+(a+b+c)x-1=0$$

or

$$x^3-\left(\frac{1}{a}+\frac{1}{b}+\frac{1}{c}\right)x^2+\left(\frac{1}{ab}+\frac{1}{ac}+\frac{1}{bc}\right)x-\frac{1}{abc}=0.$$

By the relations between roots and coefficients, the roots are seen to be $1/a$, $1/b$, and $1/c$.

Another solution was also offered by Max Beberman, Shanks Village, N. Y.

2175. *Proposed by Milton D. Eulenberg, Chicago.*

Find the side of a square, given that from a point within the square the distances to three vertices taken in order are 3, 4, and 5.

Solution by Aaron Buchman, Buffalo, N. Y.

Place the square with the second vertex at the origin of a set of rectangular coordinates, and place two sides along the axes. Let the side of the square be a and let the coordinates of the given point be $P(x, y)$. From the formula for the distance between two points the following three equations can, at once, be written.

$$x^2+(y-a)^2=$$
$$x^2+y^2=16$$
$$(x-a)^2+y^2=25$$

With very little manipulation the above set of equations can be solved for x and y in terms of a, so that an equation involving a only can be obtained. Thus,

$$a^4-4a^2+65=0.$$

Thus,

$$a=\sqrt{17\pm4\sqrt{14}}.$$

Since $P(x, y)$ is within the square, the only solution is

$$a=\sqrt{17+4\sqrt{14}}=5.64.$$

Other solutions were offered by: A. MacNeish, Chicago; Hugo Brandt; C. W. Trigg, Los Angeles City College; Gerald Sabin, University of Tampa; W.R. Talbot, Jefferson City, Mo.; Norman Anning, Ann Arbor, Mich; Louis F. Scholl, Buffalo, N. Y; and the proposer.

EDITOR'S NOTE: Mr. Trigg calls attention to the very great interest which this and similar problems have aroused. Solutions to problems of the same basic nature are found in magazines as follows:

SCHOOL SCIENCE AND MATHEMATICS, 1932, 1946, 1942, 1915
National Mathematics Magazine, 1937, 1941, 1942
American Mathematical Monthly, 1928, 1940, 1943.

2176. *Proposed by Daisy Coryell, Edmonton, Canada.*

Show that the system of equations has no solution

$$yx^3-(y^3-3y-1)x+y=0$$
$$x^2-y^2+3=0$$

Solution by W. R. Talbot, Jefferson City, Mo.

Substituting x^2+3 for y^2 in the first equation yields $y+x=0$. Letting $y=-x$ in the second equation gives $3=0$ which is impossible; therefore the equations have no solution.

Other solutions were offered by the following: Louis F. Scholl, Buffalo, N. Y.; Hugo Brandt, Chicago, Ill.; C. W. Trigg, Los Angeles City College; V. C.

Bailey, Evansville, Ind.; Muriel McCrum, Mill Valley, Calif.; C. S. Carlson, Northfield, Minn.; and Norman Anning, Ann Arbor, Mich.

2177. *Proposed by Norman Anning, University of Mich.*

In a triangle with sides x, $x+2$, $x+4$, if the angles are to be acute, what restrictions must be placed upon x?

Solution by V. C. Bailey, Evansville, Ind.

If angle C lies opposite the longest side, obviously it must be the largest angle. By the Law of Cosines

$$\cos C=\frac{x-6}{2x}.$$

... is positive, then all angles of the triangle will be acute. It is apparent fro... right-hand member of (1) that x must have values greater than six.

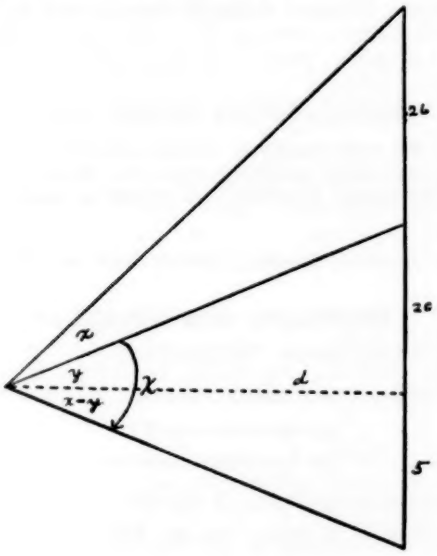
Ot... solutions were offered by the following: A. MacNeish, Chicago; C. W. Trigg... os Angeles City College; Max Beberman, Shanks Village, N. Y.; Margaret Joseph, Milwaukee, Wis.; Gerald Sabin, University of Tampa; D. McLeod, Winnipeg, Canada; Aaron Buchman, Buffalo, N. Y.; Wm. Boyle, Bloomington, Ill.; W. R. Talbot, Jefferson City, Mo.; Virgil Roonkester, Princeton, W. Va.; John Jones, Jr., Hattiesburg, Miss.; and the proposer.

2178. *Proposed by V. C. Bailey, Evansville, Ind.*

A tower 51 feet high has a mark at a height of 25 feet from the ground; find at what distance the two parts subtend equal angles to an eye at the height of 5 feet from the ground.

Solution by Louis F. Scholl, Buffalo, N. Y.

Let the required distance be d. (See figure.)



Let

$$k=\frac{1}{d}.$$

Hence

$$\tan y = 20k.$$

$$\tan (x+y) = 46k \quad \text{and} \quad \tan (x-y) = 5k.$$

$$\frac{\tan x + \tan y}{1 - \tan x \tan y} = 46k, \quad \text{also} \quad \frac{\tan x - \tan y}{1 + \tan x \tan y}.$$

Let $\tan x = a$, then

$$\frac{a+20k}{1-20ak} = 46k \quad \text{and} \quad \frac{a-20k}{1+20ak} = 5k.$$

(1) $$a = 26k - 920ak^2 \qquad a = 25k + 100ak^2.$$

Hence:

$$26k - 920ak^2 = 25k + 100ak^2.$$

Solving for a, we get

$$a = \frac{1}{1020k} = \frac{d}{1020}.$$

Substituting in (1) we get

$$\frac{d}{1020} = \frac{26}{d} - \frac{920}{1020d}$$

$$d^2 = 25{,}600,$$

$$d = 160.$$

Other solutions were offered by the following: J. A. S. Neighbors, Santa Barbara, Calif.; A. MacNeish, Chicago; C. W. Trigg, Los Angeles City College; John Jones, Jr., Hattiesburg, Miss.; Bernard Katz, Brooklyn; Wm. Crabtree, Jr., Clarksville, Tenn.; Max Beberman, Shanks Village, N. Y.; Wm. Jervis, Scranton, Pa.; Margaret Joseph, Milwaukee, Wis.; Gerald Sabin, University of Tampa; D. McLeod, Manitoba, Canada; Aaron Buchman, Buffalo, N. Y.; T. E. Rine, Normal, Ill.; W. R. Talbot, Jefferson City, Mo.; Hugo Brandt, Chicago, Ill.; Norman Anning, Ann Arbor, Mich.; and the proposer.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

2175, 6, 8. *Richard Schubert, Sterling, Morton High School, Cicero, Ill.*

PROBLEMS FOR SOLUTION

2191. *Proposed by Adrian Struyk, Paterson, N. J.*

Find equalities giving a very simple relation

(a) between x and y,

(b) between $x+y$ and $x-y$.

based upon $a + b \cos 2x + b \sin 2x \tan (x+y) = 0$.

2192. *Proposed by Francis L. Miksa, Aurora, Ill.*

Find all sets of two numbers, x and y of five digits each, such that $y = 5x$ and x and y contain all the ten digits.

2193. *Proposed by Mrs. Edith Warne, Alton, Ill.*

Solve the system

$$x^3+1/y^3=2,$$
$$1/x^3+y^3=2.$$

2194. *Proposed by Alan Wayne, Flushing, N. Y.*

What are the two ways in which fifty coins are the correct change for a dollar?

2195. *Proposed by Adrian Struyk, Paterson, N. J.*

Each side of a triangle ABC is the diameter of a semicircle. Each semicircle contains an inscribed square which has two vertices on the arc and two on the diameter. The points on the sides of triangle ABC are named according to the orders BA_1A_2C, AC_1C_2B. B_1B and C_1C intersect at A'; C_1C and A_1A at B'; A_1A and B_1B at C'. Prove that the four triangles $A'BC$, $AB'C$, ABC', $A'B'C'$ are equal in area.

2196. *Proposed by V. C. Bailey, Evansville, Ind.*

Regular inscribed and circumscribed polygons of the same number of sides have their areas in the ratio 3:4. Find the number of sides.

BOOKS AND PAMPHLETS RECEIVED

ALBERT EINSTEIN: PHILOSOPHER-SCIENTIST, Edited by Paul Arthur Schlipp. Volume VII in The Library of Living Philosophers. Cloth. Pages xvi+781. 15×23.5 cm. 1949. The Library of Living Philosophers, 101-2 Fayerweather Hall East, Northwestern University, Evanston, Ill. Price $8.50.

BASIC THEORIES OF PHYSICS, Mechanics and Electrodynamics, by Peter Gabriel Bergmann, *Associate Professor of Physics, Syracuse University.* Cloth. Pages viii+280. 14×21.5 cm. 1949. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $3.75.

RADIO OPERATOR'S LICENSE Q & A MANUAL, by Milton Kaufman, *Instructor, Department of Radio Operating, RCA Institutes, New York, N. Y.* Cloth. Pages ix+608. 13.5×21 cm. 1949. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $6.00.

PLANE AND SPHERICAL TRIGONOMETRY, by M. Richardson, Ph.D., *Assistant Professor of Mathematics, Brooklyn College.* Cloth. Pages xiv+343+xxiii+Logarithmic and Trigonometric Tables 138. 13.5×21 cm. 1950. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $3.75 with tables, without tables $3.40.

THE WORLD OF NUMBERS, ARITHMETIC 3, by Dale Carpenter, *Supervisor, Mathematics Education Section, Los Angeles City School Districts,* and Esther J. Swenson, *Professor of Elementary Education, University of Alabama.* Cloth. Pages 316. 14.5×21 cm. 1950. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $1.68.

THE WORLD OF NUMBERS, ARITHMETIC 4, by Dale Carpenter, *Supervisor, Mathematics Education Section, Los Angeles City School Districts,* and G. Lester Anderson, *Professor of Education and Dean of Teacher Education, College of the City of New York.* Cloth. Pages 316. 14.5×21 cm. 1950. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $1.68.

FROGS AND TOADS, by Herbert S. Zim. Cloth. 63 pages. 16.5×20.5 cm. 1950. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.00.

ALGEBRA, BOOK TWO, SECOND COURSE COMPLETE, by A. M. Welchons and W. R. Krickenberger, *The Arsenal Technical High School, Indianapolis, Indiana.* Cloth. Pages x+516. 14×20.5 cm. 1949. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.20.

ELEMENTS OF MATHEMATICAL ANALYSIS, by Samuel E. Urner, *Los Angeles City College* and William B. Orange, *Late of Los Angeles City College.* Cloth. Pages xi+562. 15×23.5 cm. 1950. Ginn and Company, Statler Building, Boston 17, Mass. Price $4.00.

ELEMENTS OF CALCULUS, by Thurman S. Peterson, Ph.D., *Associate Professor of Mathematics, University of Oregon,* Cloth. Pages viii+369. 15×23.5 cm. 1950. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $3.50.

SELECTED INVERTEBRATE TYPES, Edited by Frank A. Brown, Jr., *Chairman, Biological Science Department, Northwestern University, Evanston, Illinois.* Cloth. Pages xx+597. 15×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.00.

THE RADIO AMATEUR'S HANDBOOK, by the Headquarters Staff of the American Radio Relay League, West Hartford, Connecticut. 27th Edition, 1950. Paper. 736 pages. 16.5×24 cm. American Radio Relay League, West Hartford, Conn. Price $2.00 in the U.S., $2.25 in U.S. Possessions and Canada, $2.50 elsewhere.

SELF-HELP GENERAL MATHEMATICS WORKBOOK, by George E. Hawkins, *Chairman, Department of Mathematics, Lyons Township High School, and Junior College, LaGrange, Ill.*, and L. S. Walker, *Head of Mathematics Department, Niles High School, Niles, Michigan.* Paper. 80 pages. 21.5×28.5 cm. 1949. Scott, Foresman Company, Chicago, Ill. Price 72 cents.

WORKBOOK TO ACCOMPANY CURTIS AND URBAN'S BIOLOGY IN DAILY LIFE, by Francis D. Curtis, *Head of the Department of Science, University High School, Ann Arbor, Michigan, and Professor of the Teaching of Science, University of Michigan.* Paper. Pages iv+169. 18×26 cm. 1949. Ginn and Company, Statler Building, Boston 17, Mass. Price 88 cents.

TEACHERS' MANUAL TO ACCOMPANY ALGEBRA, BOOK ONE, ELEMENTARY COURSE, by A. M. Welchons and W. R. Krickenberger, *The Arsenal Technical High School, Indianapolis, Indiana.* Paper. Pages iv+27. 15.5×23.5 cm. 1949. Ginn and Company, Statler Building, Boston 17, Mass. Price 48 cents.

ANNUAL REPORT OF THE FEDERAL SECURITY AGENCY 1949, by Earl James McGrath, *Commissioner of Education.* Pages ix+102, 15×23.5 cm. Superintendent of Documents, U. S. Printing Office, Washington 25, D. C. Price 30 cents.

BOOK REVIEWS

LIFE ON OTHER WORLDS, by H. Spencer Jones, M.A., Sc.D., F.R.S., *Astronomer Royal; Honorary Fellow, Jesus College, Cambridge.* Paper. Pages viii+160. 10.5×18 cm. 1949. The New American Library of World Literature, Inc., 245 Fifth Avenue, New York 16, N. Y. Price 35 cents.

Here is a little book that is worth much more to the average reader than the price indicated. For the ordinary individual who looks skyward and wonders if there be other worlds that may be the abode of man, it answers the question as well as it can be answered. For the beginning student of the great subject of astronomy it gives a delightful start. The author first shows by a brief discussion the picture of the universe and the general conditions necessary to support life. Next he describes the methods used in the investigations. Then he tells about the

atmosphere of the earth, its present composition, what it may formerly have been, what changes may probably take place in the future, and gives the reasons for all these changes. He gives the size and describes the conditions on the great planets, showing that life can not exist there. A chapter tells of the atmosphere and surface of Venus as they can be determined by all the instruments and methods now available. Mars is the "planet of spent life" and not the home of intelligent and active beings as was conceived and described by Percival Lowell. The book closes with two interesting chapters: "The Origin of the Solar System" and "Beyond the Solar System." Twelve full page plates and brief descriptions illustrate the text, but it is necessary to read the book to get their full meaning. It is an excellent treatment of the subject at a price that anyone can afford to pay, but we would have preferred to pay ten times the price and had a book that would have held together long enough to stand reading by the reviewer and a few friends.

G. W. W.

ALBERT EINSTEIN: PHILOSOPHER-SCIENTIST, edited by Paul Arthur Schlipp. Volume VII in The Library of Living Philosophers. Cloth. Pages xvi+781. 15×23.5 cm. 1949. The Library of Living Philosophers, 101-2 Fayerweather Hall East, Northwestern University, Evanston, Ill. Price $8.50.

This is the seventh volume in The Library of Living Philosophers which began in 1939 with *The Philosophy of John Dewey*. This volume on Albert Einstein starts with his Autobiography printed in the original German on the left hand page and in the English translation on the right. This alone is worth the price of the book. Following 563 pages of "Descriptive and Critical Essays on this Work of Albert Einstein" by many of the world's greatest scientists, including Arnold Sommerfeld, Louis de Broglie, Wolfgang Pauli, Max Born, Niels Bohr, P. W. Bridgman, E. A. Milne, Karl Menger, and seventeen others, is the reply of Einstein to the criticisms made by the various scientists. From Arnold Sommerfeld's short chapter, "To Albert Einstein's Seventieth Birthday," on through the general survey of his scientific works, his contributions to Quantum Theory, his statistical theories, his departure from classical thought in modern physics, all written by some of the greatest physicists of modern times, we have a wonderful account of the developments of Einstein's time as seen by these great minds. The chapter by Niels Bohr on his discussions with Einstein on epistemological problems in atomic physics will interest every student of modern physics. We all like Bohr's fairness and modest manner of expression. Thus we might go on through all the chapters, but you will have to read to get any idea of the thought of this great philosopher and physicist. Moreover it will be useless for you to try to read it unless you have given much time to this type of discussion in the past.

In his reply to many of the great minds mentioned above Einstein says: "In what follows I wish to adduce reasons which keep me from falling in line with the opinion of almost all contemporary theoretical physicists. I am, in fact, firmly convinced that the essentially statistical character of contemporary quantum theory is solely to be ascribed to the fact that this [theory] operates with an incomplete description of physical systems."

The Bibliography of the Writings of Albert Einstein compiled by Margaret C. Shields will be a surprise to many of those who have read brief news comments on Einstein but have never made any study of his life both as a scientist and as a citizen.

G. W. W.

SCIENTIFIC AUTOBIOGRAPHY AND OTHER PAPERS, by Max Planck. Cloth. 192 pages. 13.5×21 cm. 1949. Philosophical Library, 15 E. 40th Street, New York 16, N. Y. Price $3.75.

This book is composed of five of the last papers by one of the world's greatest physicists, and a short Memorial address delivered by Max von Laue on October 7, 1947, and used here as an introduction. The first paper is an autobiography

which gives Planck's scientific thoughts and achievements in a few pages. The second paper "Phantom Problems in Science," was a lecture delivered in Göttingen June 17, 1946. The third delivered in November 1944, is a lecture on "The Meaning and Limits of Exact Science." The fourth is "The Concept of Causality in Physics." The last is a lecture on "Religion and Natural Science" delivered in May 1937. If you are not a physicist the second, third, and fourth papers will not be of great interest to you, but the last one is intensively interesting to all. Here is the summary: "It will then appear with ever increasing clarity that even though the methods are different—for science operates predominantly with the intellect, religion predominantly with sentiment—the significance of the work and the direction of progress are nonetheless absolutely identical.

"Religion and natural science are fighting a joint battle in an incessant, never relaxing crusade against scepticism and against dogmatism, against disbelief and against superstition and the rallying cry in this crusade has always been, and always will be: 'On to God!' "

G. W. W.

LEARNING ELECTRICITY AND ELECTRONICS EXPERIMENTALLY, by Leonard R. Crow, *Director of Research and Development, Universal Scientific Company, Inc.* Cloth. Pages xi+525. 13.5×21.5 cm. 1949. The Scientific Book Company, 530 South 4th Street, Vincennes, Ind. Price $4.40.

Do you want a book which beginning students can read and follow without much help from the teacher? Here is one of that type. Of course they will need some direction, they must have some classroom discussion, and some problems to solve. Work involving all these types of activities are necessary for almost everyone if he wants to learn electricity. The important condition is that this text provides all these things in a well selected sequence, with complete circuits on nearly every page, clearly drawn and completely labeled. The first 220 pages are set up with this purpose in mind: to provide all the necessary understandings, laws, circuits, and devices used in elementary electricity.

Part Two, the remainder of the book, gives the theory of alternating currents and sufficient practical work to give a complete understanding of their use in all ordinary circuits. Here is the place many books designed for elementary students fail completely because they attempt to give this in a study too rapid and too mathematical for elementary students to grasp. But in this text we have easy discussions with a sufficient number of diagrams to make the theory entirely clear before any mathematics is given. At the bottom of page 227 an entire line has been omitted by the type setter, and in the mathematical discussion on page 237 the I_m is written *Im* in several cases. These errors should be cleared up by the instructor when the assignment is made.

To show the nature of the treatment used let us look at the chapter on electrical resonance. In the beginning fifteen pages of discussion with diagrams explain much of the theory to be used. This is followed by eighteen experiments with photographs of the apparatus and circuits used. Then a few more pages explaining the use of filters and five additional experiments complete the chapter.

Enough has been said to show the nature of the book. See it before you decide on a text for your next class for practical students.

G. W. W.

THE NATURE OF PHYSICAL THEORY, by P. W. Bridgman, *Hollis Professor of Mathematics and Natural Philosophy, Harvard University; Nobel Laureate in Physics.* Cloth. Pages vi+138. Index. $5\frac{3}{8}\times 8$. Princeton University Press 1936. Reissued by Dover Publications, Inc. New York. Price $2.25.

The place of theory in human knowledge is obviously a substantial one, witness the formidable boundaries to which men's thinking *in this way* has brought us. In the realm of physical thought it has played a particularly important role since it constitutes, as we are wont to say, a step in that scheme of thinking we call scientific. Philosophers have labored on it in their classical armchair fashion

and have arrived at "theories of human knowledge." Natural philosophers have resorted to it and have brought upon themselves both ill repute and death! With all its tremendous worth as a tool in human thinking its *validity* has been subjected to very little critical inquiry. Each addition to human knowledge puts upon us two demands: (1) that it fit into the scheme of things already established as "true"; (2) that we construct an "acceptable" theory of the new phenomenon. These two demands have presented serious dilemmas in recent years on three counts:

1. Many of the new phenomena cannot fit the patterns earlier formulated;
2. The body of theory and knowledge possesses increasing complexity;
3. Explanations in the ordinary sense are now often impossible.

By this last we mean that mathematical models have no physical counterpart, or at least need have none. Wave mechanics is a classical example. And Heisenberg posed even greater dilemma by insisting that only intrinsically measurable quantities enter his equations. (And yet his notions were eminently successful.)

Professor Bridgman writes here a *critique of theory*. "For me, as a physicist," he says, "criticism is an enterprise entered into solely for practical reasons, because I find myself forced into it by the failures of my preconceptions in many practical situations."

The essay is all the more valuable because Bridgman holds eminence both as a theorist and as an experimentalist. Written originally in 1936 it examines the basic postulates of Bohr, Heisenberg, Dirac, Einstein—postulates which possess the most serious philosophic implications. By virtue of the very recent announcements of Einstein this inquiry has most timely significance.

It is not easy reading, but things worth having are hard to get!! On this count it is to be highly recommended. Its value is substantially enhanced if the reader will then go at once to Bridgman's LOGIC OF MODERN PHYSICS.

JULIUS SUMNER MILLER
Dillard University
New Orleans, Louisiana

PRINCIPLES OF A NEW ENERGY MECHANICS, by Jakob Mandelker, *Assistant Professor of Mechanics, Georgia Institute of Technology*. Cloth. Pages viii+73. 1949. Philosophical Library, 15 East 40th Street, New York. Price $3.75.

Newton's Laws stand as the postulates of *classical* mechanics, and although they have met with the most severe criticism at the hands of Mach, Hertz, Pearson, and others, they have been the foundational principles of the so-called *Newtonian* Mechanics. And for a long time this system of physical thought did well, both on earth and in the heavens! *The inertial property of matter was its ultimate basis.* The extension which Einstein proposed is well known. Indeed, it is probably the best known single isolated principle of all time, but possibly also the least understood. *Energy possesses the same inertial properties as material masses, its inertia given by* $m = E/c^2$.

The author of this monograph presents a further extension in terms of what he calls the "energical point of view," "the energical concept of matter," where the central conception of classical mechanics, the inertia-mass m is replaced by the energy conception of matter, mc^2.

The development of this thesis appears logical both in exposition and in mathematical apparatus, but the ideas and concepts deduced are somewhat novel, and our familiar equations in Newtonian and Relativistic Mechanics take on a new complexion. A "new" language and terminology arises, e.g., *matter momentum, matter energy*. Principles are newly stated, such as the Momentum-Energy Conservation Principle. Classical Mechanics turns out to be a particular limiting case of this new energy mechanics!

The basic conceptions are revised and the "New Outlook" on this energical point of view is, in the author's language, the following:

Matter is only a manifestation of an energy reality mc^2.

Mass is solely an inertia property of an existing energy.
Force, since it always involves a certain amount of mass, is also dependent upon the existence of an energy.
Work is merely a shift of a given energy from one to another level, a transformation equivalent for energy. (The text page 53.)

Whether these notions are new or whether the language alone is new must be left to the reader to decide!

The monograph can be read in one sitting but this reviewer had to read it twice to properly focus on the *apparent* newness of the ideas. It remains to be seen whether the thesis becomes acceptable.

JULIUS SUMNER MILLER

THE THIRD MENTAL MEASUREMENTS YEARBOOK, by Oscar Krisen Buros, *Editor*. Cloth. Pages xiv+1047. 18×25.5 cm. 1949. Rutgers University Press, New Brunswick, New Jersey. Price $12.50.

The Third Mental Measurements Yearbook covers the period from 1940–1947, a period which normally would have been covered by four yearbooks. The author plans to publish a yearbook every two or three years. This yearbook is a most impressive and comprehensive treatise and the author and his staff are to be highly commended for publishing it.

The section on "Tests and Reviews" lists 663 tests, 713 original reviews by 320 reviewers, 66 review excerpts, and 3,368 references on the construction, validity, uses and limitations of specific tests. This section reviews the following kinds of tests: achievement batteries, character and personality tests, intelligence tests (group and individual), sensory-motor tests, reading tests, vocations-interests tests, manual dexterity tests, mechanical ability tests, and subject matter tests. The latter includes reviews on forty-three science tests on both the secondary and college level as follows: three in science, seven in biology, fourteen in chemistry, seven in general science, nine in physics, and three in miscellaneous areas, namely astronomy, geology, and meteorology.

The section on "Books and Reviews" lists 549 books on measurement and closely related fields and 785 excerpts from reviews of these books in 135 journals. An attempt has been made to list all measurement books published in English-speaking countries between October 1940 and December 1947.

There is a periodical directory and index, publishers directory and index, index of titles, index of names, and a classified index of tests.

The yearbook will be of value to all persons using tests in one way or another. Science teachers will find the review of the forty-three science tests helpful in the selection of tests for various purposes.

KENNETH E. ANDERSON
University of Kansas

NEW DIRECTIONS IN SCIENCE TEACHING, by Anita D. Laton, *Professor of Health and Hygiene, San Jose State College*, and. S. Ralph Powers, *Professor of Natural Sciences, Head, Department of Teaching of Natural Sciences, Teachers College, Columbia University*. Cloth. 13×20.5 cm. 1949. McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 18, N. Y. Price $2.50.

This is a report of a cooperative project in seventeen secondary schools with the Bureau of Educational Research in Science of Teachers College, Columbia University.

The Bureau work consisted of three phases or intervals. The first interval was devoted to a period of exploration, during which the primary effort was to determine what scientific knowledge is requisite to an understanding of problems that people face and how that knowledge can be used for their resolution. The goal of the second interval was to prepare suggestions on how to lead young people to a clearer understanding of society, of the social function of science, and of their individual needs and interests. The work of the third interval was essentially an effort to translate the work of the first and second intervals into actual classroom

practice. This was carried on as a cooperative enterprise between the Bureau of Educational Research in Science and a number of selected schools, seventeen in all.

That the goals set for these three intervals were achieved is evident by the ensuing material presented by the authors. The authors and their associates reveal how a study of the community, young people, and current problems, resulted in more vital classroom instruction in science and related areas. These new directions in science teaching took the form of new courses within science departments, new interdepartmental courses, new emphases within existing courses, and an increased emphasis on understanding our natural resources and man's place in the universe.

Educators interested in curriculum development in the area of general education will find this volume most stimulating. Science educators will see how science instruction in these seventeen communities has been made more vital and interesting for both the college-bound and terminal student.

The real purpose of education is to effect a change of behavior in students in desirable directions. That this project has partly succeeded in doing just that in the students in these respective schools is evident. It is heartening to see curriculum workers plan for evaluation of their work. Effect was made to go beyond comparatively informal kinds of evaluation in some instances. These instances should help the traditional teacher and administrator see that the newer directions do not necessarily result in loss in conventional subject matter knowledge but in some instances may result in greater gains plus desirable development in other areas.

New Directions in Science Teaching should prove to be interesting and valuable to workers in science and to curriculum workers in general.

KENNETH E. ANDERSON

LIVING CHEMISTRY, by Maurice R. Ahrens, *Assistant Superintendent and Director of Instruction, Battle Creek Public Schools;* Norris F. Bush, *Principal, Denver Public Schools;* and Ray K. Easley, *Teacher of Chemistry, Denver Public Schools.* Revised Edition. Cloth. Pages iv+551+xxii. 22×26 cm. 1949. Ginn and Company, Chicago, 16, Illinois. Price $3.60.

This revised edition of *Living Chemistry* is even more teachable than its predecessors, and they were excellent texts. The organization and content of the revised edition are in line with the newer objectives of science instruction. The high school chemistry teacher of today is faced with a dual responsibility, that of: (1) providing the fundamentals of chemistry for college-bound students, and (2) providing a practical understanding of the role of chemistry in daily living for both college-bound and terminal students. This text will help the teacher meet this dual responsibility.

The text consists of four parts: (1) Fundamentals of Chemistry, (2) Chemistry of the Individual, (3) Chemistry of the Home, and (4) Chemistry of the Community. The four parts are further divided into units and problems, with thirty-three units in all. The practical problem approach can be illustrated by the unit on the "Chemistry of Clothing." The forward to the unit indicates the purposes to be achieved and the problems to be solved. For example, one of the purposes of the unit is "To learn the chemical properties and characteristics of the different kinds of materials used in making clothing," and one of the problems is "How are the different fabrics made?"

Aids to teaching consist of "Exercises" at the end of each problem, and "Problems for Further Study" and "Unit Exercises" in review test form at the end of each unit. In addition, each unit has a list of "References for Further Study." The appendix contains very useful additions to the text plus a comprehensive list of film aids for each unit, indicating the title of the film, length in minutes, whether it is sound or silent, the name of the company, and a short annotation. This feature is usually neglected in chemistry high school texts.

Some of the new features of the revised edition are: new treatment of the struc-

ture of matter; explanation of the nuclear energy theory; new section on properties, metallurgy, and uses of non-ferrous metals; and a new treatment of D.D.T., synthetic rubber, penicillin, waterproofing, use of propylene glycol as a preventive for colds, pasteurization, and electrolytic silver cleaning. Thus, the book stresses the needed social implications of chemistry, through a treatment of the newer developments in chemistry.

The text abounds with pictures and illustrations that are strikingly up to date. The book is thoroughly modern and covers the latest developments in chemistry. The book is one that teachers should include in their examination list for possible adoption.

KENNETH E. ANDERSON

VARIABILITY IN RECOGNIZING SCIENTIFIC INQUIRY—AN ANALYSIS OF HIGH SCHOOL SCIENCE TEXTBOOKS, by Richard H. Lampkin. Cloth. Pages ix+79. 15×23 cm. 1949. *Teachers College, Columbia University Contributions to Education No. 955.* New York: Bureau of Publications, Teachers College, Columbia University. Price $2.10.

Analyses of textbooks in the science area have been numerous but few if any have attempted to relate the analysis to recognized objectives of science instruction. Lampkin's dissertation is an exception. Lampkin defines scientific inquiry and indicates that it is considered a goal of general education as well as science education. He cites the influence of textbooks on teaching and cites evidence that teachers depend to a very large extent on their textbooks in selecting content for the courses.

His study is concerned with scientific inquiry as it appeared in selected high school science textbooks. His study was designed to answer these questions:

What is the scientific method of inquiry?

Have the authors of selected high school science textbooks explicitly accepted the scientific method of inquiry as an objective?

What ideas related to the scientific method of inquiry were discussed, or exemplified in the books?

By what means were these ideas presented?

How much space was given to them?

Was variation in the amount of space given to scientific inquiry associated with variation in such factors as the following: subject field of the book; topics within subject fields; authorship, or variation from book to book; position within the book, from quarter to quarter?

Twelve textbooks, according to certain criteria, were selected for analysis, three from each of the fields of science as taught in high school: general science, biology, physics, and chemistry. Twelve readers read the composite book. Six of the readers had a science background and six of the readers had a philosophical background.

The use of modern statistical procedures throughout the study mark a new high in this type of study. This approach adds considerably to the rigor of the analysis and makes the findings and implications more meaningful.

In general, this is an excellent piece of research in that it is well designed and well executed. The findings and implications are worthy of study by persons in science education. I recommend it as a must on reading lists for courses in the teaching of science.

KENNETH E. ANDERSON

ALCOHOL AND HUMAN AFFAIRS, by Willard B. Spalding, *Dean of the College of Education, University of Illinois;* and John R. Montague, M.D., *Vice Chairman, Educational Advisory Committee to Oregon State Liquor Commission.* Cloth. Pages vii+248. 13.5×18.5 cm. 1949. World Book Company, Yonkers-on-Hudson, New York. Price $1.64.

Written for high school students, this book treats the serious public health problem, alcoholism—an expensive and expanding disease. The authors carefully

describe both the good and bad about manufacturing alcohol. The historical, physiological, economic, legal, and personal aspects of the problem are all covered in comprehensive fashion, as an examination of the chapter headings illustrates: The Background of the Problem, The Manufacture of Alcohol, The Effect of Alcohol on the Body, The Effect of Alcohol on Society, Religion and the Use of Alcohol, What Can Be Done to Help Alcoholics, etc.

Each of these chapters is concluded by a short summary paragraph and a list of questions and things to do. The text is well organized and contains a great many charts and tables presenting the latest statistics on the subject. It is an easy book for both students and teachers to use.

Appendix A (pp. 207–216) gives brief but adequate treatment of tobacco—the history of its development, the effect of smoking on the various systems, the nicotine content in tobacco, and other aspects. Appendix B (pp. 217–240) treats narcotics and other drugs—the analgesics, sedatives and hypnotics, anesthetics, and narcotics. There is also a brief bibliography.

This book covers the subject well and should certainly be included in the reference reading shelf for students if not incorporated in a course.

GEORGE S. FICHTER
Miami University
Oxford, Ohio

HOW YOUR BODY WORKS, by Herman Schneider, *Science Coordinator, New York City Public Schools;* and Nina Schneider, *Co-author of Let's Find Out, Now Try This, Let's Look Inside Your House,* and *How Big is Big?* Pages 160. 15.5×21.5 cm. 1949. William R. Scott, Inc., Publisher, New York. Price $2.50.

How Your Body Works is a book written for students at the grade school levels. In the text, the student finds many questions: how do your eyes see, what makes your ears hear, what makes your feet go, and how do you think? The student answers these himself by solving the interesting, easy-to-perform experiments. All explanations are in a clear language at a suitable readability level, and there are numerous functional drawings. Emphasis throughout the book is on healthy children and their appreciation of the body mechanisms which maintain normal physiological functions. Students learn how to keep their bodies in good health rather than how to recognize symptoms of sickness and malfunction. Some of the general headings illustrate the book's organization and content: Food—From Taste to Digestion, How Food Gets Where It is Needed, What Your Body Is Made Of, Your Body Gets Rid of Wastes, Your Body Runs Itself, You Can Touch It, How Your Brain Works, Liquids That Give Orders, Etc. This book fills the need for a grade school text covering the subject of physiology alone.

GEORGE S. FICHTER

AN INTRODUCTION TO COLLEGE GEOMETRY, by E. H. Taylor, Ph.D., *Professor of Mathematics, Emeritus, Eastern Illinois State College,* and G. C. Bartoo, A.M., *Professor of Mathematics, Emeritus, Western Michigan College of Education.* Cloth. Pages vii+143. 14×21 cm. The Macmillan Company, New York, N. Y. 1949. Price $3.15.

This is a revision of a paper bound text which has been available for some ten years. Although definitely planned as a college text, the book would prove a valuable addition to the personal library of any plane geometry teacher. No background is assumed beyond high school geometry. Not only does this text furnish a basis for carrying the teacher or prospective teacher beyond the material usually included in high school courses but it would also provide some stimulating exercises for the superior high school student. There are many interesting historical notes.

The book is divided into two parts—the first five chapters extending the work of traditional geometry, the chapters on loci and on properties of the triangle are

especially valuable. The second portion of the text treats in general modern geometry, as illustrated by chapter titles: harmonic ranges and pencils, inversion, pole and polar, orthogonal circles, cross ratio, principle of duality. An appendix lists theorems from elementary geometry, and includes proofs of certain propositions not found in the majority of modern high school texts. There is a sufficient number of exercises to keep a class busy. Whether or not this text will suit the individual instructor is of course a matter of personal opinion; there are however relatively few texts for a course in college geometry, and this one will be worth careful consideration.

CECIL B. READ

DIFFERENTIAL EQUATIONS, by Harry W. Reddick, *Professor of Mathematics, New York University (University Heights)*, Second Edition. Cloth. Pages x+288. 14.5×22 cm. 1949. John Wiley and Sons, Inc., 440—4th Ave., New York 16, N. Y. Price $3.00.

This is the second edition of what would be classified as a standard text for a first course in differential equations. There is a considerable number of applied problems; partial differential equations are not covered. Comparison with the first edition shows a relatively small amount of change. In some cases topics appear in a slightly different order; there is an expanded treatment of some topics, notably the second order linear equation and to a smaller extent the material on hyperbolic functions and on vibratory motion. The number of problems has been markedly increased; some instructors will object to the fact that most of the problems in the earlier edition are used in this edition, with no attempt to even change numerical constants in order to provide a different set of exercises.

Those who were pleased with the first edition will no doubt also be pleased with this new edition; it is doubtful if the changes have been of sufficient importance to convert the instructor who was not satisfied with the first edition. The book merits consideration for a text in either a course emphasizing applications, or in a course with more emphasis upon theory. Answers are provided to essentially all the problems.

CECIL B. READ

STEPS IN MAP READING, by Mamie Louise Anderzhon. Paper. Pages iv+156. 20.5×26 cm. Rand McNally and Company, Chicago. List Price $0.92.

This workbook is a well organized course in map-reading. While intended for use in schools, it would be of value to anyone who needs guidance in the use and interpretation of maps. It may be used as a separate text, or it may supplement the geography textbook.

It develops the language and skills needed in map-reading and puts meaning into map symbols. It develops basic map understandings. Its explanations are simply and clearly stated. The pupil is guided so he is a doer and an active learner. The maps, diagrams, landscapes and tables he is called upon to use are provided at the points needed.

The scope of the book is indicated by the following topics: Finding Directions; Up-and-Down Directions; Maps Tell Where Places Are; Land, Water, and Shorelines on Maps; Altitude,—How High is the Land; Reading Slope from Maps; North and South of the Equator; Reading Climate from Maps; Maps Tell Us Where People Live; Transportation Routes on Maps; Political Symbols on Maps; Longitude and Time; Map Scales; Globe Distances and Directions.

VILLA B. SMITH
John Hay High School
Cleveland, Ohio

MY BOOK ABOUT OLD WORLD LANDS, by Pearl H. Middlebrook. Paper. Pages 160. 20.5×28 cm. 1949. Silver Burdett Company, Chicago. List Price $0.68.

This book for Sixth Grade pupils is based on *Old World Lands*, by Barrows, Parker and Sorensen. It is well supplied with maps, diagrams and pictures and

furnishes guidance in the use of these tools. It is an activity book at its best. The Sixth grader will find it interesting and stimulating.

VILLA B. SMITH

TEACHERS' GUIDE AND TESTBOOK TO ACCOMPANY OLD WORLD LANDS, by Beatrice Collins. Paper. Pages 151. 20.5×27 cm. 1949. Silver Burdett Company, Chicago. List Price $1.12.

This book accompanies the Sixth Grade text, *Old World Lands*, by Barrows, Parker, and Sorensen. It is an excellent guide, furnishing a time schedule for the year's work, presenting specific and general understandings for each unit and directing activities in text, map and picture reading.

The bibliography for supplementary reading is well chosen. The tests provide opportunity to measure the understanding and mastery of basic geographic ideas.

VILLA B. SMITH

THE CRAFT OF CERAMICS, by Geza deVegh and Alber Mandi. Cloth. Pages xii+145. 18.5×25.5 cm. 1949. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $3.80.

This book has been prepared for two classes of students: those who want a comprehensive, detailed, and easily understood home study text which can be used in learning the art, and those who want a means of learning for themselves and checking the details of their work even though they are regularly enrolled in class work. It is made up of a series of eleven major projects, each one divided into two, three or four principal parts. These eleven lessons together with a short general chapter on the history of ceramics, the type of clay to be used, and the methods of working it, and a final chapter describing the kilns to be used and the methods of firing them make up the text. Two short Appendixes giving a list of the important ceramic terms used and a list of the supply houses where materials may be purchased complete the volume.

The directions are clear and carefully stated, the diagrams are excellent and sixteen pages of beautiful plates show examples of finished work. This book will be of very great help to many who have never had the opportunity to cultivate hidden talents.

ALICE E. WARNER
Lakeville, Indiana

PRINCIPLES OF ORGANIC CHEMISTRY, by James English, Jr., Ph.D., and Harold G. Cassidy, Ph.D., *Associate Professors of Chemistry, Yale University, New Haven, Conn.* Cloth. Pages xiii+512. 14.5×22.5 cm. 1949. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $5.00.

This text is intended for a full-year beginning course in organic chemistry. By a careful selection of reactions and concepts which are of fundamental significance, the authors have succeeded admirably in their aim to present a textbook rather than a reference book of organic chemistry. Specialized discussions of complex compounds, complicated reactions, and exceptions to general rules which contribute little to the beginning student's understanding of the principles of organic chemistry have been omitted.

Unification of the treatment is accomplished through judicious use of the electronic theory. Well established mechanisms of important reactions are described, usually from the "initial state" rather than the "intermediate stage" viewpoint.

The writing is clear and terse. Helpful outlines and a few selected references are provided at the end of the chapters. An ample number of exercises, carefully designed to test the student's understanding rather than just his memory, are included following each chapter.

Teachers who treat aliphatic and aromatic compounds together should cer-

tainly give this text careful consideration. Some of those who do not may be won over to the use of that order of presentation by this book.

C. A. VENDERWERF
University of Kansas

A FIRST COURSE IN ALGEBRA, Second Revision by N. J. Lennes and J. W. Maucker, *Dean, School of Education, Montana State University, Missoula, Montana.* Cloth. Pages xi+561. 20½×14 cm. Macmillan Company, 60 Fifth Ave., New York, N. Y. $2.40.

This is a revision of a text published by Mr. Lennes in 1942. He has retained most of the features of the previous work along with many of the problems and explanations. The arrangement has been changed some, explanations and illustrations now appear on the same page. A feature of the previous book, "A Talk With the Students," has been much improved by more directness and an improved vocabulary which is more meaningful to the high school student. This is a valuable chapter in the book.

An interesting feature is a short paragraph at the beginning of each chapter entitled "Target For Chapter ———." These are well written and point out the important ideas of each chapter. The paragraph also gives an illustration of what this knowledge will help one do. As a follow-up, the chapter is closed with "Did We Hit the Target?" This paragraph contains questions and problems. It is assumed that ability to do these insures the pupil that he has hit the target. These paragraphs are well done although in some cases the ability to do the exercise may not assure real accomplishment.

Basic principles, rules and illustrations are boxed and in black type. At various places in the book are found topics which are to be used for discussion.

All exercises are arranged in groups A, B, or C, going from the simplest to the most difficult. The A group forms a simple case that most beginning algebra students can master. By and large this text is perhaps less difficult than previous editions.

There is considerable material which provides maintenance in arithmetic, such as exercises in addition of mixed numbers, other fundamental operations, and the relation of place value to our number system.

The approach to signed numbers is direct and the idea of direction well presented. This chapter was changed from number 6 to number 3. Transposition is still included, but it is presented after the development of the basic principles in the solution of equations.

The final chapter deals with the history of mathematics, and includes a map locating the strategic points of interest. Each chapter has a cumulative review with special chapter exercises. There is a double picture spread of Newton and Einstein. There are several other pictures and drawings which are appropriate and well placed. The book is well indexed and has both trigonometric and square and square root tables. The reviewer feels that this book is a definite improvement over the previous edition.

PHILIP PEAK
Bloomington, Indiana

ALGEBRA, MEANING AND MASTERY, BOOK ONE, by Daniel W. Snader, *Professor of Mathematics, University of Illinois.* Cloth. Pages ix+502. 13.5×21 cm. 1949. John C. Winston Company, Winston Building, 1006–1024 Arch Street, Philadelphia 7, Pa. Price $2.20.

A textbook for high school use, this book contains the topics usually found in a beginning algebra text. In addition to these topics, however, there are several optional topics, and the last unit is devoted to the study of logarithms and the slide rule.

The author says that "the explanations are predicated upon the theory that learning is an active process and that correct learning must not be impeded in any way or made dependent upon the personal explanations of a teacher in

a classroom situation." His introduction of new topics begins with a long series, frequently as many as 15 or 20 statements and questions intended to make the student thoroughly familiar with the new process being studied. This will be followed by one of the hundred and thirty-five sets of problems or exercises which are given in the book. Where there may be some doubt as to complete or thorough mastery of the new topic there are numerous examples to show its application. At the close of each unit there is a unit review and also a cumulative review covering briefly that unit and all of the preceding units.

Illustration, other than the figures which are used for certain types of problems are few. There are several historical notes and some of these are accompanied by a picture of the person associated with the discovery or development of the principle involved. The print is easy to read as are the problems in the sets of examples.

It is not the purpose of this review to decide whether this textbook provides the meaning and mastery of algebra which the title indicates the author thinks he is bringing about. It does not follow the traditional outline in many respects, containing much more written material than many algebra books. Those who are interested in following new types of textbooks in their attempts to teach algebra will want to examine this book.

ALBERT R. MAHIN
Indianapolis, Indiana

PRACTICAL SHOP MATHEMATICS. VOLUME II—ADVANCED, by John H. Wolfe, Sc.D., *Formerly Director of Apprentice Training, Fort Motor Company*, and Everett R. Phelps, Ph.D., *Professor of Physics, Wayne University*. Third Edition. Cloth. Pages xiv+356. 12×19.5 cm. 1949. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $2.60.

The third edition of this book has been revised to bring it up to date. The sections on compound angle problems have been rewritten to teach the student the elementary principles of pictorial drawing. Solid geometry theorems are presented in connection with the problems they represent.

In most problems one letter or dimension of the formula is given six or seven values as a variable so that in assigning problems each student may be assigned the same problem, but have different answers because of the variable involved. This feature is retained from the earlier editions.

The first three chapters discuss compound angles and their various applications to shop work, chapter four screw threads, the next three chapters gears, their ratios and planetary gearing, chapter eight, plain and differential indexing, and chapter nine, combining fractions and continued fractions.

A factor table and an answer table for some of the problems completes the book. According to the authors *Practical Shop Mathematics* retains the well-liked features of earlier editions.

ALBERT R. MAHIN

MODERN-SCHOOL SOLID GEOMETRY, by Rolland R. Smith, *Coordinator of Mathematics, Public Schools, Springfield, Massachusetts* and John R. Clark, *Professor of Education, Teachers College, Columbia University*. New Edition. Cloth. Pages vii+256. 16×14 cm. 1949. World Book Company, Yonkers-on-Hudson, New York. Price $1.76.

This book presents the topics usually covered in a secondary school course in Solid Geometry in about the sequence that experienced teachers have come to regard as standard. While there is nothing particularly remarkable about either the content or the methods in this text the fact remains that it is a workman like performance by thoroughly [illegible] writers.

The inductive development of [illegible]cepts is facilitated by the inclusion of developmental exercises immediately [illegible] each new topic or proposition. These are intended for class discussion. P[illegible]ses are placed after a topic that has been developed to provide the [illegible]ctice in applying it.

In addition to the developmental and proficiency exercises there are also chapter tests at the end of each chapter and review exercises at intervals throughout the book. The authors have also included pages for "Maintaining Skills" which the teacher may find useful in reviewing topics from arithmetic and algebra which the pupils have studied in previous years.

The text is well organized along traditional lines and merits consideration by those seeking a newer copyright.

FRANK B. ALLEN
La Grange, Illinois

GENERAL CHEMISTRY—A SYSTEMATIC APPROACH, by Harry H. Sisler *of The Ohio State University* and Calvin A. Vanderwerf and Arthur W. Davidson *of The University of Kansas*. Cloth. Pages x+846+24. 15×23.5 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $5.00.

This is a textbook for use in college first-year chemistry classes. The title of the book accurately describes the teaching viewpoint of the authors, which is first to build a firm foundation of the more important theoretical concepts of modern chemistry and then to follow this with a study of the chemistry of the various groups of elements, building always on the earlier foundations. On the theoretical side atomic and molecular structure, stoichiometric principles, and periodic relationships are stressed. These concepts are logically developed and should appeal especially to the more thoughtful students. It is this portion of the book that is truly distinctive and is particularly well written.

The theoretical and the descriptive sections overlap less than in most other current texts; the first descriptive portion on oxygen, hydrogen, and water appearing only after a theoretical development of 200 pages. The usual sequence of laboratory work should therefore be altered if it is to be synchronized with the text. Fortunately, a laboratory manual, *A Systematic Laboratory Course in General Chemistry*, designed to accompany this text and to carry its approach in the laboratory, is being published this spring.

The text abounds in simple but instructive line drawings, in well chosen tables, and in photographs of modern atomic and molecular models. Other photographs are well selected but are fewer in number than in most texts. Pictures of famous personalities in chemistry are practically absent. The Study Questions and Problems that follow each chapter are designed to be thought-provoking rather than to involve memory of details or the use of intricate mathematics. This follows the general pattern of the book in emphasizing the mastery of principles.

LEONARD C. KREIDER
Wadsworth, Ohio

GENERAL CHEMISTRY, by Harry N. Holmes, *Oberlin College*, Fifth Edition. Cloth. Pages vi+708. 15×22 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York, N. Y.

General Chemistry attempts to achieve two objectives. One of the objectives is to lay a firm foundation for the student who plans to take advanced courses in chemistry. The other purpose is to give the student who plans to take only a single course in chemistry, an understanding and appreciation of chemistry in particular, and of science in general.

The text is organized logically as to subject matter. The fundamental principles are presented simply and clearly, and these principles are illustrated by means of examples and problems throughout the text. The uses, occurrence, and production of various substances are discussed wherever possible. This will add to the interest of the subject.

The text is broad in scope and well suited for use in an introductory course in college chemistry.

FRED KURATA
University of Kansas